

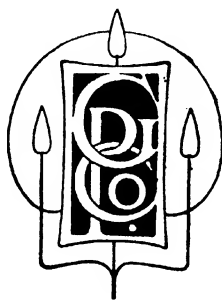
MODERN INDUSTRIAL CHEMISTRY

From the German of
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Publishers' Note

This standard work, now for the first time issued in an English translation, is designed to cover the whole range of subjects with which the chemist and manufacturer are usually concerned. It is not intended as a textbook, but to occupy a position between the textbook and the lexicon. The strict alphabetical arrangement permits of easy reference; the short, concise treatment limits the work to reasonable proportions.

In accordance with the plan the book deals with all the most important products used in chemical industry and in the laboratory, with the materials used in their preparation, and with the apparatus and instruments. In the various articles, so far as is possible, are given the formulae, atomic weights, molecular weights, the usual graphic formulae, specific gravities, melting-points, boiling-points, coefficients of solubility, thermochemical and electrochemical constants, &c.

The manual provides a survey of chemical technology, summarizes the many subjects which it is impossible for the specialist to know, and enables the enquirer to obtain readily the desired information on matters with which he is but imperfectly acquainted.

For a considerable period the manual has been an almost essential part of the equipment of factories and laboratories of the chemist, pharmacist, and manufacturer in Germany, and the critics of various journals, and other competent judges, both in Germany and elsewhere, are unanimous in their praise of the contents of the book, and also of the additions and improvements which have characterized the numerous successive editions.

In order to prevent the work from assuming unwieldy proportions, old and unimportant methods have been omitted, or the length of the articles has been curtailed in accordance with their relative importance. On the other hand, special attention has been paid to the careful annotation of the literature of patents. In cases where the importance of the patent does not seem great enough to warrant a lengthy description, the name of the country granting it and the number are accurately given. Only by careful selection and by attempting to estimate the relative importance of different subjects has it been possible to confine the book within reasonable limits.

The Publishers confidently anticipate that the English edition will fill a real gap in British technical literature, and will be as successful as the German original.

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List of Abbreviations

Amer. Pat.	= American Patent	Germ. Pat.	= German Patent
Amp.	= Ampère	H. P.	= Horse power
Atm.	= Atmosphere	K. W.	= Kilowatt
A. W.	= Atomic Weight	M. P.	= Melting Point
°Bé.	= Degrees Baumé	S. G.	= Specific gravity
B. P.	= Boiling Point.	Temp.	= Temperature
EMF.	= Electromotive force	V.	= Volt
Eng. Pat.	= English Patent	Vol.	= Volume

Symbols and Formulæ used in this Work

Symbol or Formula	Name	Symbol or Formula	Name
Ag	Silver	$\text{CH}_3\cdot\text{Cl}$	Methyl chloride
AgCl	Silver chloride	CH_3I	" iodide
AgNO_3	Silver nitrate	$\text{CH}_3\cdot\text{NH}_2$	Methylamine
Ag_2S	Silver sulphide	CH_3OH	Methyl alcohol
Ag_2SO_4	Silver sulphate	$(\text{CH}_3)_2\text{O}$	" ether
Al	Aluminium	CH_4	Methane
AlCl_3	" chloride	$(\text{CN})_2$	Cyanogen
Al_2Cl_6	" chloride	CO	Carbon monoxide
Al_2F_6	" fluoride	COCl_2	Phosgene
Al_2O_3	" oxide	$\text{CO}(\text{NH}_2)_2$	Urea
$\text{Al}_2(\text{OH})_6$	" hydroxide	CO_2	Carbon dioxide
$\text{Al}_2(\text{SO}_4)_3$	" sulphate	CS_2	" disulphide
As	Arsenic	C_2H_2	Acetylene
AsCl_3	Arsenic trichloride	$\text{C}_2\text{H}_2\text{O}_4$	Oxalic acid
As_2Cl_6	" "	C_2H_4	Ethylene
As_2O_3	Arsenious oxide	$\text{C}_2\text{H}_3\text{O}_2$	Acetic acid
As_2O_5	Arsenic oxide	$\text{C}_2\text{H}_5\text{Br}$	Ethyl bromide
Au	Gold	$\text{C}_2\text{H}_5\text{Cl}$	" chloride
AuCl_3	Gold trichloride	$\text{C}_2\text{H}_5\text{I}$	" iodide
B	Boron	$\text{C}_2\text{H}_5\text{NH}_2$	Ethylamine
B_2O_3	Boron trioxide	$\text{C}_2\text{H}_5\cdot\text{OH}$	Alcohol (ethyl)
Ba	Barium	$(\text{C}_2\text{H}_5)_2\text{O}$	Ether (ethyl)
BaCO_3	" carbonate	C_2H_6	Ethane
BaCl_2	" chloride	$\text{C}_3\text{H}_5\cdot\text{OH}$	Allyl alcohol
$\text{Ba}(\text{ClO}_3)_2$	" chlorate	$\text{C}_3\text{H}_5(\text{OH})_3$	Glycerine
BaCrO_4	" chromate	$\text{C}_3\text{H}_7\cdot\text{OH}$	Propyl alcohol
$\text{Ba}(\text{NO}_3)_2$	" nitrate	$\text{C}_3\text{H}_5\text{O}_3$	Glycerine
$\text{Ba}(\text{OH})_2$	" hydroxide	$\text{C}_4\text{H}_6\text{O}_6$	Tartaric acid
BaO_2	" peroxide	$\text{C}_5\text{H}_5\text{N}$	Pyridine
BaS	" sulphide	$\text{C}_6\text{H}_{11}\cdot\text{OH}$	Amyl alcohol
BaSO_4	" sulphate	$\text{C}_6\text{H}_2(\text{NO}_2)_3\text{OH}$	Picric acid
Bi	Bismuth	$\text{C}_6\text{H}_4(\text{CH}_3)\text{NH}_2$	Toluidine
$\text{Bi}(\text{NO}_3)_3$	Bismuth nitrate	$\text{C}_6\text{H}_4\cdot(\text{CH}_3)_2$	Xylene
Br	Bromine	$\text{C}_6\text{H}_4\cdot(\text{CO}_2\text{H})_2$	Phthalic acid
C	Carbon	$\text{C}_6\text{H}_4(\text{NH}_2)_2$	Phenylene diamine
$\text{CCl}_3\cdot\text{C}(\text{OH})_2$	Chloral	$\text{C}_6\text{H}_4(\text{OH})\text{CO}_2\text{H}$	Salicylic acid
CCl_4	Carbon tetrachloride	$\text{C}_6\text{H}_4(\text{OH})\text{NH}_2$	Amidophenol
CHBr_3	Bromoform	$\text{C}_6\text{H}_5\text{O}_2$	Quinone
CHCl_3	Chloroform	$\text{C}_6\text{H}_5\cdot\text{CH}_3$	Toluene
CHI_3	Iodoform	$\text{C}_6\text{H}_5\cdot\text{CO}_2\text{H}$	Benzoic acid
CH_3Br	Methyl bromide	$\text{C}_6\text{H}_5\text{Cl}$	Chlorobenzene
$\text{CH}_3\cdot\text{CO}_2\text{H}$	Acetic acid	$(\text{C}_6\text{H}_5)_2\text{NH}$	Diphenylamine
		$\text{C}_6\text{H}_5\cdot\text{NH}_2$	Aniline
		$\text{C}_6\text{H}_5\cdot\text{NO}_2$	Nitrobenzene

SYMBOLS AND FORMULÆ

Symbol or Formula	Name	Symbol or Formula	Name
$C_6H_5.OH$	Phenol	$FeCl_3$	Ferric chloride
C_6H_6	Benzene	FeO	Ferrous oxide
$C_6H_{10}O_5$	Cellulose, Starch.	FeS	" sulphide
$C_6H_{12}O_6$	Glucose	$FeSO_4$	" sulphate
$C_{10}H_7.NH_2$	Naphthylamine	Fe_2Cl_3	Ferric chloride
$C_{10}H_7.NO_2$	Nitronaphthalene	$Fe_2(OH)_6$	Ferric hydroxide
$C_{10}H_7.OH$	Naphthol	Fe_2O_3	" oxide
$C_{10}H_{16}$	Naphthalene	$Fe_2(SO_4)_3$	" sulphate
$C_{12}H_{22}O_{11}$	Terpene	Fe_2S_3	" sulphide
$C_{14}H_{18}O_2$	Cane sugar		
$C_{14}H_{10}$	Anthraquinone	H	Hydrogen
Ca	Anthracene	$HAuCl_4$	Chloro-auric acid
$Ca(OX)_2$	Calcium	HBr	Hydrobromic acid
CaC_2	" carbonate	$HBrO_3$	Bromic acid
$Ca(C_2O_4)_2$	" carbide	HCN	Hydrocyanic acid
$CaCl_2$	" oxalate	H. COH	Formaldehyde.
$CaCrO_4$	" chloride	H. CO ₂ H	Formic acid
CaF_2	" chromate	HCl	Hydrochloric acid
$CaHPO_4$	" fluoride	$HClO_3$	Chloric acid
	" hydrogen phos-	$HClO_4$	Perchloric acid
$Ca(NO_3)_2$	" nitrate	Hf	Hydrofluoric acid
CaO	" oxide	HI	Iodic acid
$Ca(OH)_2$	" hydroxide	HIO_3	Iodic acid
$Ca(OC)_2$	" hypochlorite	HNO_3	Nitric acid
CaO_2	" peroxide	HVO_3	Vanadic acid
CaS	" sulphide	H_2O	Water
$Ca(SH)_2$	" hydrosulphide	H_2O_2	Hydrogen peroxide
$CaSO_4$	" sulphate	H_2MoO_4	Molybdic acid
Ca_2PbO_4	" plumbate	H_2PtCl_6	Chloro-platinic acid
$Ca_2(PO_4)_3$	" phosphate	H_2S	Sulphuretted hydrogen
Cd	Cadmium	H_2SO_4	Sulphuric acid
$CdCl_2$	" chloride	H_2SiF_6	Hydrofluosilicic acid
$CdSO_4$	" sulphate	H_2SnO_3	Metastannic acid
Ce	Cerium	H_3BO_3	Boric acid
Cl	Chlorine	H_3PO_4	Phosphoric acid (ortho)
Co	Cobalt	H_4SnO_4	Stannic acid
$CoCl_2$	" chloride (ous)	H_4WO_6	Tungstic acid
$Co(NO_3)_2$	" nitrate	Hg	Mercury
$CoSO_4$	" sulphate	$HgCl_2$	Mercuric chloride
Co_2Cl_6	" chloride (ic)	$Hg(NO_3)_2$	" nitrate
Cr	Chromium	HgO	" oxide
CrO_3	Chromic anhydride	HgS	" sulphide
Cr_2Cl_6	Chromium chloride	$HgSO_4$	" sulphate
Cr_2F_6	" fluoride	Hg_2Cl_2	Mercurous chloride
$Cr_2(OH)_6$	" hydroxide	$Hg_2(NO_3)_2$	" nitrate
Cr_2O_3	" trioxide		
Cu	Copper	I	Iodine
$CuCl_2$	Cupric chloride	Ir	Iridium
$Cu(NO_3)_2$	" nitrate		
CuO	" oxide	K	Potassium
CuS	" sulphide	KBr	" bromide
$CuSO_4$	" sulphate	$KBrO_3$	" bromate
Cu_2Cl_2	Cuprous chloride	$KC_2H_3O_2$	" acetate
Cu_2S	" sulphide	$KC_2H_3O_6$	" bitartrate
		KCN	" cyanide
F	Fluorine	KCNS	" thiocyanate
Fe	Iron	KCl	" chloride
$FeCl_2$	Ferrous chloride	$KClO_3$	" chlorate
		$KClO_4$	" perchlorate

SYMBOLS AND FORMULÆ

xv

Symbol or Formula	Name	Symbol or Formula	Name
KF	Potassium fluoride	NH ₄ I	Ammonium iodide
KHCO ₃	" bicarbonate	NH ₄ NO ₃	" nitrate
KHSO ₃	" bisulphite	(NH ₄) ₂ SO ₄	" sulphate
KHSO ₄	" bisulphate	NO	Nitric oxide
KI	" iodide	NO ₂	Nitrogen dioxide
KMnO ₄	" permanganate	N ₂ O	Nitrous oxide
KNO ₂	" nitrite	N ₂ O ₃	Nitrogen trioxide
KNO ₃	" nitrate	N ₂ O ₄	" peroxide
KOH	" hydroxide	N ₂ O ₅	" pentoxide
K ₂ CO ₃	" carbonate	Na	Sodium
K ₂ C ₂ O ₄	" oxalate	NaBr	" bromide
K ₂ C ₄ H ₄ O ₆	" tartrate	NaBrO ₃	" bromate
K ₂ CrO ₄	" chromate	NaCN	" cyanide
K ₂ Cr ₂ O ₇	" bichromate	NaC ₂ H ₃ O ₂	" acetate
K ₂ O	" oxide	NaCl	" chloride
K ₃ Pt(CN) ₄	" platinumcyanide	NaClO ₂	" chlorite
K ₃ PtCl ₆	" platinumchloride	NaClO ₃	" chlorate
K ₂ S	" sulphide	NaClO ₄	" perchlorate
K ₂ SO ₃	" sulphite	NaF	" fluoride
K ₂ SO ₄	" sulphate	NaHCO ₃	" bicarbonate
(K ₂ SO ₄) ₂ Al ₂ (SO ₄) ₃	" alum	NaHSO ₃	" bisulphite
K ₂ SiF ₆	" silicofluoride	NaHSO ₄	" bisulphate
K ₂ SiO ₃	" silicate	NaH ₂ PO ₄	" dihydrogen phosphate
K ₃ PO ₄	" phosphate	NaI	" iodide
Li	Lithium	NaMnO ₄	" permanganate
LiCl	" chloride	NaNH ₂	Sodamide
Li ₂ CO ₃	" carbonate	NaNO ₂	Sodium nitrite
Li ₂ SO ₄	" sulphate	NaNO ₃	" nitrate
Mg	Magnesium	NaOCl	" hypochlorite
MgCO ₃	" carbonate	NaOH	" hydroxide
MgCl ₂	" chloride	NaPO ₃	" metaphosphate
Mg(NO ₃) ₂	" nitrate	Na ₂ Al ₂ O ₄	" aluminate
MgO	" oxide	Na ₂ B ₄ O ₇	" borate (borax)
Mg(OH) ₂	" hydroxide	Na ₂ CO ₃	" carbonate
MgSO ₄	" sulphate	Na ₂ CrO ₄	" chromate
Mn	Manganese	Na ₂ Cr ₂ O ₇	" bichromate
MnCO ₃	" carbonate	Na ₂ O	" oxide
MnCl ₂	" chloride	Na ₂ O ₂	" peroxide
MnO ₂	" dioxide	Na ₂ S	" sulphide
MnSO ₄	" sulphate	Na ₂ SO ₃	" sulphite
Mo	Molybdenum	Na ₂ SO ₄	" sulphate
N	Nitrogen	Na ₂ S ₂ O ₃	" thiosulphate
(NH ₂) ₂	Hydrazine	Na ₂ SnO ₃	" stannate
NH ₂ .OH	Hydroxylamine	Na ₂ WO ₄	" tungstate
NH ₃	Ammonia	Na ₂ PO ₄	" phosphate
NH ₄ Br	Ammonium bromide	Na ₄ P ₂ O ₇	" pyrophosphate
NH ₄ .CNS	" thiocyanate	Ni	Nickel
NH ₄ Cl	" chloride	NiCl ₂	" chloride
NH ₄ ClO ₃	" chlorate	NiO	" oxide
NH ₄ ClO ₄	" perchlorate	NiS	" sulphide
(NH ₄) ₂ CrO ₄	" chromate	NiSO ₄	" sulphate
(NH ₄) ₂ Cr ₂ O ₇	" bichromate	Ni ₂ (OH) ₆	" hydroxide
NH ₄ HS	" hydrosulphide	Ni ₂ O ₃	" oxid
(NH ₄) ₂ HPO ₄	" hydrogen phosphate	O	Oxygen
		O ₃	Ozone
		Os	Osmium
		P	Phosphorus

SYMBOLS AND FORMULÆ

Symbol or Formula	Name	Symbol or Formula	Name
PCl_3	Phosphorus trichloride	SiO_2	Silicon dioxide (silica)
PCl_5	" pentachloride	Sn	Tin
POCl_3	" oxychloride	SnCl_2	Stannous chloride
P_2O_5	" pentoxide	SnCl_4	Stannic chloride
Pb	Lead	SnO_2	Tin oxide
PbCO_3	" carbonate	SnS	Stannous sulphide
$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$	" acetate	SnS_2	Stannic sulphide
PbCl_2	" chloride	Sr	Strontium
PbCrO_4	" chromate	SrCO_3	" carbonate
PbI_2	" iodide	SrCl_2	" chloride
$\text{Pb}(\text{NO}_3)_2$	" nitrate	$\text{Sr}(\text{NO}_3)_2$	" nitrate
PbO	" oxide	SrO	" oxide
PbO_2	" peroxide	$\text{Sr}(\text{OH})_2$	" hydroxide
PbS	" sulphide	SrSO_4	" sulphate
PbSO_4	" sulphate		
Pb_2O_3	" sesquioxide		
Pb_2O_4	Minium	Te	Tellurium
Pd	Palladium	Ti	Titanium
Pt	Platinum	Th	Thallium
PtCl_4	" tetrachloride		
		U	Uranium
Rb	Rubidium	UO_2	" oxide
Rh	Rhodium	UO_2Cl_2	Uranyl chloride
		$\text{UO}_2(\text{NO}_3)_2$	" nitrate
S	Sulphur		
SO_2	" dioxide	V	Vanadium
SO_2Cl_2	Sulphuryl chloride	V_2O_5	" pentoxide
SO_3	Sulphur trioxide		
Sb	Antimony	W	Tungsten
SbCl_3	" trichloride		
SbCl_5	" pentachloride	Zn	Zinc
Sb_2S_3	" trisulphide	ZnCO_3	" carbonate
Sb_2S_6	" pentasulphide	ZnCl_2	" chloride
Se	Selenium	ZnO	" oxide
Si	Silicon	$\text{Zn}(\text{OH})_2$	" hydroxide
SiC	" carbide	ZnS	" sulphide
SiCl_4	" tetrachloride	ZnSO_4	" sulphate
SiF_4	" tetrafluoride	Zr	Zirconium

A.

Abietic acid (SYLVIC ACID). The chief constituent of Colophony; crystallizes in leaves; soluble in alcohol M. P. 139°—147°.

Abraun salts, known also as Stassfurt or Potash salts. Under this term are included various salts which occur in thick layers in the Stassfurt deposits. At first reckoned worthless they are now highly valued as artificial manures, and in addition serve as the source of many chemical preparations e. g. KCl, K_2SO_4 , $MgSO_4$, Na_2SO_4 , $MgCl_2$, Boric acid, Bromine, etc.

The most important of the Stassfurt salts are: Boracite, Carnallite, Kainite, Schoenite, and Sylvine.

CARNALLITE, $KCl \cdot MgCl_2 \cdot 6 H_2O$, is the principal source from which the commercial potash manures are obtained.

KAINITE, $K_2SO_4 \cdot MgSO_4 \cdot MgCl_2 \cdot 6 H_2O$, is used for the same purpose. Carnallite is the raw material from which potassium chloride is prepared, while from kainite potassium magnesium sulphate and potassium sulphate are obtained.

Sylvine is practically pure potassium chloride and may be regarded as a secondary decomposition product of carnallite.

SCHOENITE, $K_2SO_4 \cdot MgSO_4 \cdot 6 H_2O$, is pure potassium magnesium sulphate. As it always occurs intimately mixed with kainite it must be worked with the latter and admits of no direct treatment.

KIESERITE, $MgSO_4 \cdot H_2O$, is crystallized magnesium sulphate $MgSO_4 \cdot 7 H_2O$ which has lost six molecules of water of crystallization. Since it is sparingly soluble in water it must be first treated differently as it occurs intimately, mixed with "Steinsalz" and anhydrite. The kieserite of commerce is always either artificially prepared or it is obtained as a by-product.

BORACITE. What is known as Boracite is really a mixture of two different salts, crystalline boracite, $2 Mg_3B_2O_{15} \cdot MgCl_2$, and hydroboracite, $CaB_2O_4 \cdot MgB_2O_4 \cdot 6 H_2O$. The former is easily soluble in water while the latter is almost insoluble.

Crystalline boracite is also known by the name of Stassfurtite. It is used for the preparation of boric acid (see art. Boric acid).

The preparation of special salts is described under the heading of the respective metals, e. g. potassium chloride, art. "Potassium compounds".

From the mother-liquors of the carnallite preparations are obtained bromine (see Bromine), ferrous bromide (see Bromine compounds), and potassium bromide (see Potassium compounds).

It may be mentioned that the so-called "Hartsalz" belongs to the Stassfurt series and is a mixture of sylvine, "Steinsalz" and kieserite. The "Hartsalz" of Leopoldshall contains 18—20 % sylvine, 30—40 % Steinsalz, 40—50 % kieserite, and 3—8 % water.

Absorption. **ABSORPTION APPARATUS.** Absorption apparatus of different kinds is used in the manufacture of acids, for the drying of gases, the recovery of nitric acid etc. etc. Mention may be made of the Lunge-Rohrmann towers in which plates are used, the "Kypke-Türme" and the Guttman tower.

Blücher.

Of considerable importance is the Cellarius patent Cooling and Condensing apparatus. The object of this apparatus, constructed of earthen ware, is to render available the heat generated which was formerly wasted. By this means greater efficiency of absorption is attained and the life of the apparatus is prolonged. The apparatus is so arranged, that the nozzles for both the incoming and outgoing water are immersed in the cooling vessel, so that in addition to the fluid in the lower part of the apparatus, which is cooled by the water, the gases themselves are also cooled by contact with the walls of the condenser.

The arrangement is such that not only are the gases presented to a relatively large surface of liquid, but that they are constantly exposed to a fresh layer of the absorbent since they are forced to pass in a wide steam along the curved surface of the base of the vessel which is further provided with a ledge running the whole length. The gases must pass from the end of the vessel along the strongly-cooled walls and roof, then spread out in a broad stream, and so come in contact with a constantly renewed surface of liquid.

The outflow is placed near the entrance so that the gases pass twice along the whole length of the vessel. This apparatus is specially adapted for the absorption of gases such as HCl, SO₂, HBr etc., but is also capable of general application.

Earthen ware absorption vessels:

Westdeutsche Steinzeug-Chamotte- und Dinas-Werke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Absorption coefficient. The coefficient of absorption of a gas is measured by the volume absorbed by one volume of the liquid at any given temperature under atmospheric pressure (the volume of the gas being reduced to 0° and 760 mm of mercury).

The coefficient of absorption for water is usually calculated according to the formula $\alpha = A + B \cdot T + C \cdot t^2$, where α is the desired coefficient, T the observed temperature, and A, B and C the coefficients which must be determined for each gas. For the most important gases these values are known from the work of Bunsen and Carius. The following tables give extracts from Bunsen's work.

	A	B	C	The coefficients are valid between
Chlorine	+ 3,0361	— 0,046196	+ 0,0001107	0° and 40° C.
Carbon dioxide	+ 1,7967	— 0,07761	+ 0,0016424	0° „ 20° C.
Oxygen	+ 0,4115	— 0,00108986	+ 0,000022563	0° „ 20° C.
Sulphuretted hydrogen .	+ 4,3706	— 0,083687	+ 0,0005213	0° „ 40° C.
Nitrogen	+ 0,020346	— 0,00053887	+ 0,000011156	0° „ 20° C.
Hydrogen	+ 0,0193	—	—	0° „ 20° C.

The coefficients of absorption calculated from the above are here given together with those of other gases.

I. COEFFICIENTS OF ABSORPTION FOR WATER.

1 volume of water dissolves at 760 mm pressure:	0° C.	4° C.	10° C.	15° C.	20° C.
Ethane	0,0874	0,0748	0,0599	0,0508	0,0447
Ethylene	0,2568	0,2227	0,1837	0,1615	0,1488
Ammonia	1049,6	941,9	812,8	727,2	645,0
Butane	0,03147	0,02770	0,02355	0,02417	0,02065

1 volume of water dissolves at 760 mm pressure:	0° C.	4° C.	10° C.	15° C.	20° C.
Carbon monoxide . . .	0,03287	0,02987	0,02635	0,02432	0,02312
Carbon dioxide . . .	1,7987	1,5126	1,1847	1,0020	0,8014
Air	0,02471	0,02237	0,01953	0,01795	0,01704
Methane	0,05449	0,04993	0,04372	0,03909	0,03499
Oxygen	0,04114	0,03717	0,03250	0,02989	0,02838
Sulphuretted hydrogen	4,3706	4,0442	3,5858	3,2326	2,9053
Sulphur dioxide . . .	79,789	69,828	56,647	47,276	39,374
Nitric oxide	0,31606	0,30290	0,28609	0,27478	0,26592
Nitrous oxide	1,3052	1,1346	0,6196	0,7778	0,6700
Nitrogen	0,02035	0,01838	0,01607	0,01478	0,01403
Hydrogen	0,01930	0,01930	0,01930	0,01930	0,01930

II. COEFFICIENTS OF ABSORPTION FOR ALCOHOL.

1 volume of water dissolves at 760 mm pressure:	0° C.	4° C.	10° C.	15° C.	20° C.
Ethylene	3,5950	3,3750	3,0859	2,8825	2,7131
Carbon monoxide . . .	0,20443	0,20443	0,20443	0,20443	0,20443
Carbon dioxide	4,3295	3,9736	3,5140	3,1993	2,9465
Methane	0,52259	0,51135	0,49535	0,48280	0,47096
Oxygen	0,28397	0,28397	0,28397	0,28397	0,28397
Sulphuretted hydrogen	17,891	15,373	11,992	9,539	7,415
Sulphur dioxide	328,62	265,81	190,31	144,55	114,48
Nitrous oxide	4,1780	3,9085	3,5408	3,2678	3,0253
Nitrogen	0,12634	0,12476	0,12276	0,12142	0,12038
Hydrogen	0,06925	0,06867	0,06786	0,06725	0,066688

Acajou balsam (CARDOL). Obtained from the fruits of *Anacardium occidentale* (Mahogany nuts, Elephant nuts) by extraction of the powdered nuts with ether-alcohol and washing the extract with water in order to remove the tannic acid.

The chief constituent of the balsam is cardol — the balsam is known as raw cardol (*Cardolum vesicans*). This is used medicinally as a blister and it is also employed for the preparation of indelible inks and colours for diesinking work.

From the fruits of *Anacardium orientale* a similar product also known as cardol (*Cardolum pruriens*) is prepared.

Acacia rubber see "Rubber".

Accidents. FIRST ASSISTANCE ACCORDING TO ESMARCH.

In all cases of accident the first principle of the unprofessional helper must be: "Do no harm!"

IN CASES OF WOUNDS. Above all no entrance of dirt. Therefore no lint, no plaster, no sponge, no soiled linen, no dirty fingers, *but* only rinsing, with pure water, still better with boiled water, best of all with some antiseptic such as a solution of carbolic acid, salicyl, creolin, or such like.

Into this dip clean linen or cotton wool for bandages. Should the wound be covered with congealed blood it should not be removed. Care must be taken to avoid this. If bright red blood spurts out in violent jets it means that an artery is severed and there is danger to life. A doctor must be instantly called. Until he comes see that the limb is held up above the horizontal line and that the artery is tightly pressed *above* the wound.

DISLOCATIONS. These can be recognised by the difference in shape between the injured limb and the uninjured one. The joint must be set as soon as possible, but only by the doctor. Avoid any experiments, keep the patient quiet and wait for the doctor.

SPRAINS. In these cases there is no change in the shape of the limb, but a swelling of the joint. Every movement is painful. Keep the patient quiet until the doctor comes. Cold compresses and cold bandages, may be applied, but there must be no rubbing and no massage.

BURNS AND SCALDS. The doctor must be fetched at once and till he comes, keep the patient in a warm room. Lying either on the floor or a table, *not in bed*. The clothes must be very carefully removed. Where necessary cut the garments with a sharp knife or scissors so that they fall off of themselves. Be careful neither to pull nor tear to avoid breaking the blisters. This is most important. Should the blisters be very full prick them with a clean needle. If the patient suffer from thirst give a warm strengthening drink such as tea or other stimulant.

Apply no cold bandages. If an apothecary is near, send for antiseptic ointment for burns or iodoform powder, which will soothe the pain. Also creoline or salicylic acid can be applied, whereupon cover with cotton wool or muslin. If none of these remedies are to be obtained take oil, dripping, butter, syrup, talc or flour. The principal thing is to protect the burnt skin from the effects of air. Should a person have fallen into a lime pit or into soap lye, he must be at once put into water and washed with a solution of vinegar.

DROWNING. Every drowned person must be regarded as asphyxiated or lifeless, but the methods for restoration must be carried on, though apparently without hope. The essential thing is the restoration of respiration. The patient must be laid on his stomach with one arm under the head. The head and breast slightly lower than the body. Cleanse the mouth and nose from slime and drag the tongue forwards. Place snuff in the nose, tickle the inside of the throat with a feather, rub the breast and face, sprinkle and beat with a wet cloth. If all this has no result turn the patient on his back, with the head a little raised and encourage breathing by pressing on the chest.

When breathing begins wrap in warm blankets and if possible put at once in a warm bed with hot stones or bottles and give warm drinks.

FROZEN PEOPLE. Such patients must be brought into a closed cold room, on no account into a warm one. Rub down with snow or cold wet cloths, then place in an ice-cold bath. Apply strong aromatic salts of sal volatile. As restorative drink give cold wine or coffee.

ASPHYXIATION. The unconscious patient must be carried into the fresh air, but this must be done with care so that the helper himself does not choke. Open or break all windows and doors to get fresh air. If in a well be careful only to descend after tying round the mouth a cloth saturated with diluted vinegar or lime water.

UNCONSCIOUSNESS. Remove first of all the collar or any other covering from the throat. See that there is plenty of fresh air. If the patient is pale lay him with the head lower than the body. If the face is red, prop up the head.

SUNSTROKE. Carry to a cool spot, unfasten the clothing, fan the patient, sprinkle profusely with cold water and give much cold water to drink.

POISONING. Insure in the first place that the patient vomits either by giving him an emetic, or much warm water, or tickling the inside of the throat with feathers or such like. Of course at once send for the doctor. See also the articles on *Poisons* and *Antidotes*.

THE REMOVAL OF THE SICK AND WOUNDED must be carried out with extreme care on some kind of stretcher. Only two persons should carry. The third

should take care of the patient and if necessary, take a turn in carrying. Place the shutter or door in a line with the patient and draw him backwards on to it.

The bearers should *not* keep step, or the patient will be unduly shaken. Start one bearer with the right, the other with the left foot; this will make the motion regular and rhythmic. Take short steps. The bearers should be of about the same height.

Accumulators. The usual electrical accumulator, made of spongy lead and lead peroxide with H_2SO_4 as an electrolyte, has come to be generally used but is objectionable on account of its great weight. In consequence many investigations have been made with the object of devising an accumulator in which lead is not used. The first suggestion was the use of copper and zinc in caustic potash solution but owing to its marked inefficiency it had no more success than that of a later device in which cadmium was substituted for zinc.

Later Edison took out patents for a new cadmium accumulator in which the one electrode was cadmium, the other cuprous oxide, but until now this has had no commercial success. The same remark must be applied to the interesting silver peroxide-copper accumulator in which caustic potash is used as electrolyte.

The nickel oxide accumulator which was so warmly welcomed has up to the present found little application on account of the fact that the saving in weight compared with the lead accumulator is more than counter balanced by its limited capacity and great sensitiveness. In the first nickel accumulator of Michalowski the negative electrode was zinc. The one devised later by Edison differed from this in that the electrode was of iron (afterwards of cadmium). In its latest form the Edison accumulator has both electrodes of nickel steel, the positive one being covered with a layer of nickel peroxide, the negative with a similar layer of finely divided iron. The electrolyte is a solution of caustic potash (20–30 %).

According to German Patent 147 468 a coating of graphite is applied to the electrodes and a similar method is adopted in the German Patent 158 800.

The Jungner accumulator differs only slightly from the Edison Nickel-accumulator. In this instrument the active elements are of nickel and iron oxide compounds strongly compressed between gratings of nickel-plated steel. In many trials the Jungner-Edison accumulator has been proved to be efficient, but it is doubtful whether it will displace the lead accumulator.

The German Patent 142 714 provides for the preparation of nickel electrodes by making a paste of nickel salts, applying this to the frame-work of the electrodes, treating for a short time with alkali and then converting the nickel oxide so formed into a highly oxidized form by the action of the electric current.

The German Patent 159 393 protects the method of preparing nickel electrodes with the addition of small quantities of silver, the object being to increase the capacity.

Of considerable interest is the accumulator devised by Auer von Welsbach, the discoverer of the principle of incandescent lighting. In his apparatus he makes use not of the chemical alteration of the electrodes, but of the alternate oxidation and reduction of the electrolyte which consists of a solution of cerium sulphate. The ceric sulphate is reduced to cerous sulphate by the hydrogen set free at the cathode, and this is subsequently easily reoxidized. The positive electrode is carbon, the negative one is zinc and the two are separated by a diaphragm made of parchment-paper.

This accumulator should possess a greater electromotive force than the lead accumulator and be of greater efficiency. Since shaking favours its

action, it would seem that it is specially adapted for motor-car purposes. It remains however to be seen whether this accumulator will be a commercial success.

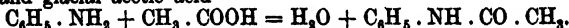
Up to now one remains *in statu quo ante* with regard to the lead accumulator.

Acetals. A class of compounds formed by the combination of an alcohol and aldehyde with separation of water. Of the various acetals methylal (methyl dimethyl ether) is of importance. It is prepared from formaldehyde. See METHYLAL.

Acetal itself (Methyl acetal) or ethylidene diethyl ether $\text{CH}_3 \cdot \text{CH}(\text{OC}_2\text{H}_5)_2$ is a liquid of S. G. 0.8314 (at 20°); it boils at 104° and is formed during the process of making brandy.

Acetaldehyde see ALDEHYDE.

Acetanilide (ANTIFEBRINE) $\text{C}_6\text{H}_5 \cdot \text{NH} \cdot \text{CO} \cdot \text{CH}_3$. Prepared by prolonged heating (1 to 2 days) together under an inverted condenser of equal parts of aniline and glacial acetic acid



The reaction is carried out in vessels made preferably of earthenware.

Acetates see under respective metals.

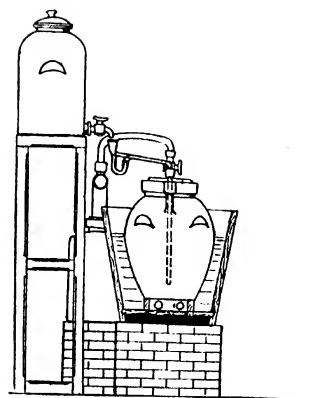
Acetic acid.

$\text{C}_2\text{H}_4\text{O}_2 = \text{CH}_3 \cdot \text{CO} \cdot \text{OH}$. Acetic acid is obtained from crude wood vinegar (see special articles on wood vinegar and charcoal manufacture). The process is first to distil off the methyl alcohol and then to obtain the wood vinegar by distillation. It is a colourless liquid containing empyreumatic ingredients which render it unfit for purposes of consumption. These empyreumatic substances are not completely removed by direct treatment although several patents for this purpose have been taken out. A good process is first to produce acetate of calcium or sodium, then to skim off the layer of tar which collects on the surface of the liquid, to separate the clear liquid from the precipitate and finally to evaporate the solution so obtained. In some cases the above process is repeated. The resulting crystals are generally redissolved, recrystallized and once more dissolved, the solution evaporated, and the salts obtained finally dried by heat. The calcined salt is easily transported so that it is explained how enormous quantities of crude acetate of lime (theso-called brownlime) produced in other countries are imported into Germany and there transformed into pure acetic acid. Generally speaking the method of producing acetic acid from Ca-salts is the one most usually adopted, and only in a few cases is sodium acetate employed for this purpose.

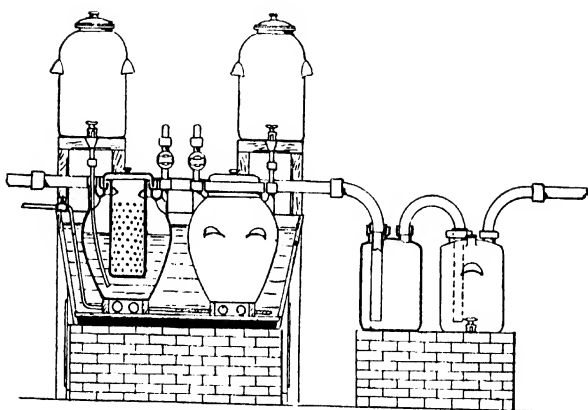
For the actual production of acetic acid the acetate is dissolved, crystallized, and after this preliminary purification decomposed with H_2SO_4 in distilling vessels of copper or earthenware. On heating, the acetic acid distils over. The distillation is now frequently carried out under reduced pressure. By this method a product of greater purity and strength is obtained in a much shorter time.

In order to obtain very concentrated acetic acid, the so-called glacial acetic acid, either calcined acetate of sodium is distilled with pure H_2SO_4 , or the ordinary acetic acid is rectified by fractional distillation.

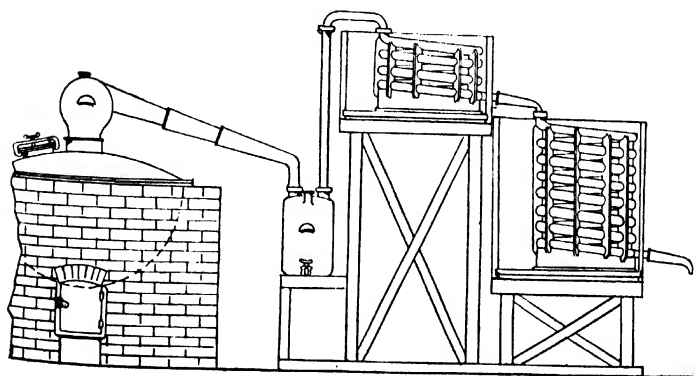
According to Rohrmann, acetic acid is obtained directly from calcium acetate in the following way: The rectifying columns contain sieve-like plates of earthenware; the vapours of acetic acid in ascending meet the liquid (H_2SO_4 for instance) flowing over the sieves and are thus purified and concentrated. By means of a series of sloping plates and tubes the various sieve-plates are connected with each other.



CHLORINE APPARATUS (End View)



CHLORINE APPARATUS (Side View)



ACETIC ACID APPARATUS

(All by Doulton & Co., Ltd., Lambeth)

According to the German Patent 146 103, concentrated acetic acid is obtained from calcium acetate by dissolving the latter completely or in part in acetic acid of at least 50 %, and the acetate decomposed by passing sulphur dioxide into the solution. The acetic acid is separated from the calcium sulphite either by filtration or by distillation.

The German Patent 130 439 treats of the production of acetic acid directly from crude wood vinegar without the intermediate formation of an acetate. In fact, in the one operation the pyroligneous acid is separated from the tar and at the same time is purified and concentrated. The process is based upon the property possessed by the acid sulphates of the alkali metals of separating tarry constituents from pyroligneous acid and also upon the fact that they have a greater affinity for water than for acetic acid. 1—2 parts of bisulphate are heated with 2 parts of acetic acid and after the tar is separated the filtered solution is subjected to fractional distillation under either atmospheric or diminished pressure. When the contents of the vessel begin to foam strongly, distillation is interrupted, a fresh portion of the crude acid added and the distillation recommenced. The process is repeated as often as required, the tarry constituents separated and corresponding fractions of a certain number of previous operations are mixed and placed in a distillation apparatus. According to the amount of acetic acid contained 1—2½ times the amount of bisulphate is added. The contents of the vessel are distilled and the distillate refractionated. This is repeated until all the acid is separated into two fractions, one containing concentrated acid of 80—70 %, and the other a dilute solution (about 0.2 %). The acid should be entirely free from tar and ready for immediate commercial use. In consequence of the homologous fatty acids present, it is not suitable for table purposes. To obtain chemically pure acid and glacial acetic acid, the processes above mentioned must be carried out.

According to the American Patent 714 484, acetic acid can be prepared by passing dry HCl gas over calcium acetate which is heated to a temperature above the B. P. of acetic acid.

Pure acetic acid is a colourless liquid with a penetrating smell and is strongly corrosive; sp. gr. at 15° C. 1.055 33. At 16.7° it crystallizes in shining translucent leaves. It is volatile at the ordinary temperature. Boiling point 181.1°.

Acetic acid:

Domeier & Co. Ltd., 8 Harp Lane, London E.C.

Earthenware acetic acid apparatus:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Acetic acid distilling apparatus of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Acid pumps:

C. Harzer & Co., Finsbury Pavement House London E.C.

Acid proof vessels:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Acid stand vessels:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Acetic acid is largely used in dyeing, in fabric printing and for medical purposes. In a dilute form it is used as vinegar. For household use it is sold as essence of vinegar to which is usually added certain substances to improve the flavour. One part of this essence diluted with 10 parts of water gives a vinegar suitable for table use. Essence of vinegar diluted (1:10 H₂O) yields a normal food vinegar.

Table of sp. gr. of acetic acid at 15° according to Oudemans.

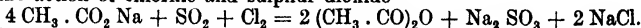
S. G.	Per- centage	S. G.	Per- centage	S. G.	Per- centage	S. G.	Per- centage	S. G.	Per- centage	S. G.	Per- centage
0,9992	0	1,0242	17	1,0459	34	1,0623	51	1,0725	68	1,0739	85
1,0007	1	1,0256	18	1,0470	35	1,0631	52	1,0729	69	1,0736	86
1,0022	2	1,0270	19	1,0481	36	1,0638	53	1,0733	70	1,0731	87
1,0037	3	1,0284	20	1,0492	37	1,0646	54	1,0737	71	1,0726	88
1,0052	4	1,0298	21	1,0502	38	1,0653	55	1,0740	72	1,0720	89
1,0067	5	1,0311	22	1,0513	39	1,0660	56	1,0742	73	1,0713	90
1,0083	6	1,0324	23	1,0523	40	1,0666	57	1,0744	74	1,0705	91
1,0098	7	1,0337	24	1,0533	41	1,0673	58	1,0746	75	1,0696	92
1,0113	8	1,0350	25	1,0543	42	1,0679	59	1,0747	76	1,0686	93
1,0127	9	1,0363	26	1,0552	43	1,0685	60	1,0748	77	1,0674	94
1,0142	10	1,0375	27	1,0562	44	1,0691	61	1,0748	78	1,0660	95
1,0157	11	1,0388	28	1,0571	45	1,0697	62	1,0748	79	1,0644	96
1,0171	12	1,0400	29	1,0580	46	1,0702	63	1,0748	80	1,0625	97
1,0185	13	1,0412	30	1,0589	47	1,0707	64	1,0747	81	1,0604	98
1,0200	14	1,0424	31	1,0598	48	1,0712	65	1,0746	82	1,0580	99
1,0214	15	1,0436	32	1,0607	49	1,0717	66	1,0744	83	1,0553	100
1,0228	16	1,0447	33	1,0615	50	1,0721	67	1,0742	84		

In order to obtain the essence from fermentation vinegar, the latter according to the German Patent 140 220, is treated with an equivalent amount of Na H SO_4 , and the solution distilled until a temperature of 125° is reached. Then the liquid removed by distillation is replaced by a fresh quantity of vinegar and the whole operation repeated. After a considerable number of distillations the extractives are separated from the bisulphate and are added to the concentrated essence. In order to concentrate the vinegar purified by the first distillation, two to three times the amount of Na H SO_4 is added and the whole fractionated. Fractions of the same concentration from several distillations are mixed and again distilled with bisulphate. By this means an acid of 60 % strength is easily obtained. This method has the particular advantage that the ethers upon which the aroma of the vinegar depend, are not lost and that the acid is concentrated without the intermediate formation of the calcium salt.

The fact that essence of vinegar may be easily produced from dry acetates while fermented vinegar, itself weak, must be concentrated in some way so as to become the essence of vinegar suitable for the household is naturally a great obstacle to the fermented vinegar industries.

Acetic anhydride $(\text{CH}_3 \cdot \text{CO})_2\text{O}$. Produced by distillation of a mixture of acetyl chloride and sodium acetate or of a mixture of anhydrous sodium acetate and phosphorus oxychloride.

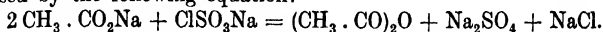
According to German Patent 127 350 it is produced from sodium acetate by the action of chlorine and sulphur dioxide



There are other methods for making the anhydride, most of which are also patented. Instead of phosphorus oxychloride use is made of other chlorides, as for instance acetyl chloride, phosgene, sulphuryl chloride. In the case of sulphuryl chloride the reaction is practically identical with the equation given above.

The German Patent 132605 treats of a process of obtaining acetic anhydride from acetates by the use of sulphur chloride. The reaction takes place under reduced pressure, and the acetic anhydride distils over at 52°, a temperature at which no SO_2 is formed. If conducted at the ordinary pressure, the distillation would yield a product greatly contaminated with SO_2 .

According to the German Patent 146 690 acid anhydrides can be obtained by the action of the salts of chlor sulphonic acid upon the salts of organic acids. In order to prepare acetic anhydride 150 kilo of sodium chlorosulphonate are heated with 170 kilo of anhydrous sodium acetate. The reaction begins at 70° with a considerable evolution of heat, when part of the anhydride distils. The rest is obtained by heating to 200°—250°. The change is expressed by the following equation:



According to the French Patent 354 742 acid anhydrides can be prepared by heating the anhydrous salts of organic acids with silicon tetrafluoride (obtained by heating together fluor spar, sand and sulphuric acid). In the case of acetic anhydride the gas is allowed to act on anhydrous sodium acetate at a temperature of 200°—220°. The gas is rapidly absorbed and the anhydride distils over.

The German Patent 161 882 describes a method of obtaining the anhydrides of monobasic organic acids by means of sulphuryl chloride, using instead of the salts of the alkalies a mixture of these with the salts of the alkaline earths. The dry salt mixture is cooled and treated with the sulphuryl chloride. For instance 164 kg. of fused and then pulverised sodium acetate are well mixed with 158 kg. of dry calcium acetate and then decomposed with 135 kg. sulphuryl chloride. The whole is well stirred and cooled, and the resulting acetic anhydride separated by filtration.

It is a colourless, mobile liquid, with a penetrating smell, sp. Gr. (at 20° C.) 1.073; boiling point 137°.

Acetic compounds see articles ACETOL, ACETONE &c.

Acetic Ester (ACETIC ETHER, ETHYL ACETATE) $\text{CH}_3 \cdot \text{CO}_2 \cdot \text{C}_2\text{H}_5$. Obtained by distilling a mixture of ethyl alcohol and acetic acid with sulphuric acid, or by distilling sodium acetate and sulphuric acid with alcohol. In the latter case ethyl sulphuric acid ($\text{C}_2\text{H}_5 \cdot \text{HSO}_4$) is obtained as an intermediate product.

It is a colourless mobile, neutral liquid with a fruity smell. S. G. (15°) 0.9068. B. P. 77°. Easily inflammable, burning with a smoky flame. Soluble in 9 parts of water. Mixes in all proportions with alcohol, ether, fatty and essential oils. It is used medicinally, for the preparation of fruit-essences (used in perfumery and in the manufacture of liqueurs), and also in large quantities for the preparation of different kinds of smokeless powder.

Acetic Ether:

C. Erdmann, Leipzig-Lindenau.

Acetic Ether apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Acetone. A mixture of various acetyl derivatives of glycerine. It is prepared by mixing equal parts of pure glycerine (28° Baumé) and glacial acetic acid, allowing the mixture to stand for 12 hours and then heating to 140° whilst a current of dry air is drawn through until no further distillate is obtained. The residue contains the acetone while the distillate is 60 % acetic acid which is used for future operations.

Acetone is used either in a neutral form or in one containing about 20 % free acid. In the former case as much as possible of the acid is removed by distillation: in the latter, this is not carried so far and the requisite amount of free acid must be subsequently added.

Acetone is used in dyeing.

Acetoacetic ester $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_2 \cdot \text{COO} \cdot \text{C}_2\text{H}_5$.

In order to prepare acetoacetic ester 20 g of metallic sodium are dissolved in 200 g of ethyl acetate. A sodium derivative is formed $\text{CH}_3 \cdot \text{COCHNaCOO} \cdot \text{C}_2\text{H}_5$. The excess of ethyl acetate is removed by distillation and to the

residue 110 g. of 50 % acetic acid are added and, after cooling, 100 g. of water. The layer of acetoacetic ester which separates at the top is rectified by distillation and the fraction coming over between 175° and 185° is collected.

It is a pleasant-smelling liquid, S. G. 1.0256 (at 20°), B. P. 181°; slightly soluble in water; easily volatile in steam. It is a very reactive substance and plays an important part in many condensation reactions.

Acetocaustine:

Dr. L. C. Marquart chem. Fabrik, Beuel a. Rhein, Germany.

Acetol. The alcohol derived from acetone $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_2 \cdot \text{OH}$. The salicylic ester is known as Salacetol (see this art.). This substance is not to be confused with the acetol used as a photographic developer (see PHOTOGRAPHIC CHEMICALS).

Acetol silver lactate $\text{C}_3\text{H}_5\text{O}_3\text{Ag} + \text{H}_2\text{O}$. Used as an antiseptic and also in the form of an aqueous solution for steeping the silk and catgut materials employed for stitches.

Acetometer see VINEGAR.

Acetone (DIMETHYL KETONE) $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_3$. Is prepared commercially from dry calcium acetate by slowly decomposing the latter at a temperature below 300° and condensing the vapours by rapid cooling. According to another method the vapours of acetic acid are passed over porous baryta heated to 350°–400° and the products cooled in ice. According to German Patent 144 328 the substance from which acetone is prepared is employed in a moist state and is heated in retorts to a red heat. This arrangement prevents irregularities and overheating of the walls of the retort.

According to the American Patent 719 223 carbonates of the alkaline earths are heated with carbon and then treated with nitrogen. A cyanide is formed which is heated with acetic acid. HCN is given off and the residual acetate is reconverted by heat into a carbonate whilst acetone is formed. The carbonate is used in future operations.

According to the French Patent 361 379 the vapours of acetic acid are led over a heated acetate, the distillation vessel being filled with porous material, such as broken coke, in order to increase the active surface.

The German Patent 170 533 is based upon the decomposition of calcium acetate into acetone and CaCO_3 , but since at a temperature of 500° the latter dissociates into CaO and CO_2 , the whole process is carried out in a stream of CO_2 in order to prevent the formation of quicklime which exerts a decomposing action upon the acetone.

The English Patents 25 993 and 25 994 (1901) are concerned with the recovery of acetone from smokeless powder, the property acetone has of combining with bisulphites being here made use of. The mixture of acetone and air is drawn through towers supplied with a solution of bisulphite. The sulphate produced by oxidation in the towers is crystallized out by cooling and from the residual liquid the acetone is obtained by distilling with alkalis, or better, it is simply distilled off and the small quantity of SO_2 formed by decomposition converted into bisulphite by the addition of alkali before the whole is rectified. The bisulphite so formed is used for future operations. The towers are filled with a network of pack-thread stretched on frames closely packed together. Running along the length of the frames are grooves by means of which the bisulphite solution is distributed and in order to prevent this from evaporation the mixture, before it passes into the absorption tower is passed through a tower saturated with water vapour. The method which is also described in Ger. Patent 154 124, should give excellent results.

The crude acetone is purified by treatment with quicklime, distillation over NaHO and finally by distillation with sodium sulphite.

Colourless liquid having an ethereal smell and a burning taste. S. G. 0.7921 (at 18°), B. P. 56°. Soluble in water, alcohol, ether and chloroform. It dissolves almost all resins, fats, ethereal oils and nitrocellulose (guncotton). It is used in the dyeing and varnish industries, in the preparation of iodoform and of recent years in the manufacture of smokeless powder.

Acetone:

Domeier & Co. Ltd., 8 Harp Lane, London E.C.

Acetone oils are by-products obtained in the commercial preparation of acetone. They consist of ketones, aldehydes, condensation products of acetone &c. and are separated in the first distillation. They are sold in two grades, light (B. P. 75°—130°) and heavy (B. P. 130°—270°) and are used in the purification of anthracene.

Acetone sulphite see "PHOTOGRAPHIC CHEMICALS".

Acetophenone (PHENYLMETHYL KETONE) $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_5$. Used as a drug under the name *Hypnone*. It is obtained by heating benzene and acetyl-chloride with Al_2Cl_3 . The fraction distilling between 190° and 200° is redistilled and the portion coming over between 195° and 200° collected.

Acetophenone is a colourless or yellowish oily liquid boiling at 201°. At 4° it solidifies to a mass of leaves, melting at 20°. Almost insoluble in water, very soluble in alcohol, ether, chloroform, benzene and fixed oils.

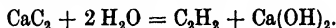
It is prescribed as a hypnotic in the form of capsules, the dose being from 0.05 to 0.15 gramme.

Acetyl chloride. $\text{CH}_3 \cdot \text{CO} \cdot \text{Cl}$. A colourless pungent liquid obtained by the action of PCl_3 and POCl_3 upon acetic acid. According to the German Patent 151 864 the acetates of the alkaline earths (e. g. calcium acetate) are intimately mixed with sulphuryl chloride and the whole distilled, when acetyl chloride passes over.

Of importance is the method described in German Patent 146 690 according to which acetyl chloride is obtained by heating together to a temperature of 150°—200° 1 molecule of anhydrous sodium acetate and 2 molecules of sodium chlorosulphonate, $\text{SO}_3 \cdot \text{Cl} \cdot \text{Na}$.

Acetyl chloride decomposes readily in presence of water, and this reaction is of great importance because of the great ease with which the substance reacts with various compounds.

Acetylene C_2H_2 . A gaseous hydrocarbon now always prepared by the action of water upon calcium carbide at the ordinary temperature. The reaction proceeds according to the equation:



At the atmospheric pressure, acetylene is a colourless gas of S. G. 0.92 (air = 1). Under a pressure of 48 atmospheres it is condensed at 1° to a highly refractive liquid of S. G. 0.451 (at 0°). Acetylene burns with a smoky but exceedingly brilliant flame. By means of specially-constructed burners the smokiness can be avoided, and the light obtained is fifteen times greater than that obtained from an equal amount of ordinary coal-gas. One objection to the use of acetylene is the fact that mixed with air it is explosive. The most dangerous mixture is one consisting of 1 part acetylene with 12 parts of air, but any mixture consisting of 1 part acetylene with a volume of air varying from 1.25 up to 20 is explosive. In acetylene gas plant the danger of explosions is almost entirely prevented by limiting the size of the openings of the burners.

Pure acetylene has scarcely any poisonous action and possesses an aromatic smell. The commercial gas has an objectionable odour and poisonous properties due to the presence of sulphides and compounds of phosphorus and hydrogen. These impurities are removed by the use of special absorption apparatus.

On a commercial scale 1 kilo of calcium carbide yields 300 litres of acetylene. The cost of acetylene lighting can be estimated from the following data. 1 kilo CaC_2 costs three pence, yielding 300 litres acetylene. This amount gives per hour light equivalent to 500 candle power, so that 0.6 litres gas gives one standard candle-power-hour. (This estimate includes merely the cost of the calcium carbide.)

Although under proper management, acetylene gas forms an excellent and safe lighting medium, yet liquid acetylene is a dangerous material to handle and frequently explodes from no ascertainable cause.

Of wide application is the use of a solution of acetylene in acetone. 1 litre of acetone dissolves at atmospheric pressure 24 litres and at a pressure of 12 atmospheres, 300 litres.

For calcium carbide see the article "CARBIDE".

Lunge and Cederkreutz employ bleaching powder for the purification of acetylene but the use of this material is the cause of sudden explosions. According to Germ. Pat. 162 324 such explosions may be prevented by the use of a special kind of bleaching powder of the composition CaO , CaOCl_2 , H_2O which may be formed by the action of chlorine upon slaked lime provided that the reacting substances are kept cool.

The method of removing phosphine from acetylene by passing the gas through a strong acid such as H_2SO_4 is open to the objection that after a time the phosphine is no longer absorbed. The German Patent 179 994 seeks to remove this objection by the addition of As_2O_3 which is said to make the effect of the acid more lasting.

Acetylene heating. When acetylene is burnt with pure oxygen a temperature is attained which closely approximates to that obtained in the electric arc (i.e. 3500°). The essential condition for the application of acetylene for heating purposes, as for example in the welding of iron in which it is particularly useful, is the employment of a good burner in which the mixing of the gases can be regulated and explosions avoided.

Acetyllith. This name is given to a preparation of calcium carbide coated with sugar. When this is used the unpleasant evolution of acetylene, which takes place after the removal of the water, is obviated. As a consequence, the carbide which has not been acted upon remains unaltered in the reservoir, and it only requires a fresh addition of water to promote again the evolution of the gas.

Acetylsalicylic acid. (ASPIRIN) $\text{C}_6\text{H}_4(\text{CO}_2\cdot\text{CH}_3)\cdot\text{CO}_2\text{H}$. In order to prepare this compound salicylic acid is boiled with acetic anhydride, or salicylic acid is heated with acetyl chloride to 80° . In either case a crystalline mass is obtained which is recrystallized from chloroform.

According to the American Patent 749 980 acetyl salicylic acid can be prepared by heating together salicylic acid, sodium acetate and the chloride of p. toluene sulphonic acid. Instead of the acid an ester of salicylic acid may be used, in which case the corresponding ester of acetyl salicylic acid is obtained.

The English Patent 15 517 (1902) is concerned with the preparation of salts of this acid.

Colourless crystals (needles) having an acid taste. M. P. 135° ; moderately soluble in water, easily in alcohol and ether.

It is a valuable drug which has to a large extent replaced salicylic acid in the treatment of rheumatism and neuralgia. Dose: 0.5 g. As much as 4 g. may be given daily.

Acidimetry see ALKALIMETRY.

Acidol. (BETAINE HYDROCHLORIDE) $\text{CH}_2\text{N}(\text{CH}_3)_3 \text{Cl} \cdot \text{CO}_2\text{H}$. This compound forms colourless crystals easily soluble in water. The solution possesses an acid taste like that of fruit. The crystals contain 23.8 % HCl. Because of its ready hydrolytic dissociation in aqueous solution it should prove, as a drug in a convenient solid form, a valuable substitute for HCl, particularly in diseases of the digestive system.

0.5 g of acidol in the solid form is equivalent to 10 drops of 12.5 % HCl.

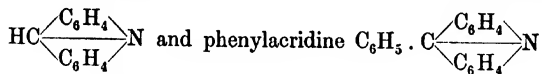
Acidol pepsin. A stable preparation of pepsin and hydrochloric acid obtained from pepsin and acidol. It is sold in two strengths and possesses good digestive properties.

Acoin. (DIPARAANISILMONOPHENETYLQUANIDINE HYDROCHLORIDE.) Has been recently much used as a drug. It is employed as a local anaesthetic and is said to possess many advantages over cocaine.

Aconitin. An alkaloid prepared from Aconite (*Aconitum napellus*). The formula is unknown but is probably $\text{C}_{34}\text{H}_{47}\text{NO}_{11} + \text{H}_2\text{O}$. It is obtained from the tubers of the aconite by extraction with 90 % alcohol at a temperature of 60°. Aconitin and its salts are used in medicine. Great care in its use is necessary, since it is one of the strongest plant poisons known. The different preparations possess different toxic powers. The usual dose is 0.0003 g with a maximum dose of 0.006 g per diem.

Acopyrin. (ANTIPYRINE ACETYSALICYLATE.) A white crystalline powder easily soluble in alcohol, very insoluble in water. It is prescribed in cases of acute rheumatism and also in fevers and for head-aches.

Acridine Dyes. The parent substances of the acridine dyestuffs are acridine



The acridine dyestuffs have an arrangement similar to that of anthracene. They are derived from di- and triphenyl methane and may also be regarded as being connected with the pyrones and rhodamines.

Acridine yellow is the hydrochloride of diamidodimethylacridine. It is obtained by the action of formaldehyde upon m-toluylenediamine. Ammonia is then split off from the product resulting from this action and the substance so obtained is oxidised.

Acrolein see GLYCERINE.

Adeps lanae see WOOL FAT.

Adeps mineralis see VASELINE.

Adeps petrolei see VASELINE.

Adeps suillus see LARD.

Adhesives. Many materials are used for the preparation of adhesives, such as gum arabic, glue, dextrine, solutions of caseine &c. The following kinds are usually recognised:—

A. OIL CEMENTS mixtures of mineral substances in a powdered form with linseed oil or varnish.

1. GLAZIER'S PUTTY. A mixture of whitening and linseed oil: hardens more quickly when zinc oxide, litharge or minium is added to the mixture.

A similar preparation is also obtained when asphalt is mixed with chalk and fatty oils. According to the German Patent 154 220 the asphalt and chalk may be replaced by bituminous limestone.

2. **DIAMOND METAL CEMENT.** 10 parts whitening, 15 pts. litharge, 50 pts. graphite, 5 pts. calcium hydroxide and 20 pts. linseed oil varnish. This must be warmed before use.

3. **METAL CEMENT FREE FROM LEAD.** 8 pts. barium sulphate, 6 pts. graphite, 3 pts. calcium hydroxide and 3 pts. boiled linseed oil.

4. **METAL CEMENT.** 100 pts. MnO_2 , 5 pts. white lead, 3 pts. minium, 3 pts. alumina (clay), 12 pts. graphite, 18 pts. varnish. Another recipe is the following:—2 pts. minium, 5 pts. white lead, 4 pts. dry alumina (clay) and sufficient varnish to give the right consistency. Finally, the following is highly recommended:—9 pts. mastic are melted with 27 pts. linseed oil and 9 pts. white lead and 18 pts. litharge are stirred into the mixture. This must be used hot.

5. **MASTIC CEMENT (Stone cement):** A mixture of sandstone, limestone and litharge; 100 pts. of the powder are mixed with 7 pts. oil-varnish.

6. **STONE CEMENT.** (Paget's mastic): 21 pts. chalk, 63 pts. sand, 5 pts. white lead, 2 pts. litharge, kneaded to a paste with a saturated solution of acetate of lead and finally mixed with 6 pts. linseed oil.

7. **QUICK DRYING CEMENT:** White lead, plaster of Paris, linseed oil with a little water.

8. **WATER PROOF STONE CEMENT:** 2 pts. kieselguhr, 1 pt. litharge, 2 pts. calcium hydroxide, mixed with varnish.

B. **RESIN CEMENTS.** Consisting of resin solutions or molten resin mixtures: waterproof, elastic, but not resistant to heat.

1. **MASTIC CEMENT (Amber cement):** Equal parts of mastic and linseed oil melted together.

2. **GLASS AND CHINA CEMENT:** 30 pts. shellac, 10 pts. mastic, 2 pts. turpentine, 110 pts. alcohol.

3. **WOOD CEMENT:** Thick alcoholic solution of shellac. A good medium for fixing wood or glass on iron, consists of a fused mixture of equal parts of shellac and pumice-stone;—should be applied hot.

4. **RESIN CEMENT (Stone cement):** 1 pt. resin, 1 pt. sulphur, 2—3 pts. powdered stone.

5. **PUMICE-STONE CEMENT:** Equal parts powdered pumice-stone and shellac form a good cement for glass and metal, and for metal and wood or china.

6. **METAL CEMENT (for metals and wood):** 4 pts. yellow resin, 1 pt. black pitch, 2 pts. wax and 1 pt. brick powder;—to be applied hot. As good a cement is obtained by boiling 1 pt. cologne glue with 1 pt. shellac and adding 1 pt. whitening.

7. **MARINE GLUE:** 1 pt. india rubber dissolved in 12 pts. turpentine (or paraffin) and added to two parts asphalt or shellac. This marine glue, which is an extremely powerful adhesive, must be applied hot. Another receipt for rubber cement is:—2 pts. melted tallow to which are added 30 pts. finely divided rubber. The whole is melted carefully and while stirring 2 pts. minium or lime are added.

8. **GLASS PUTTY:** 1 pt. rubber, 16 pts. mastic, 64 pts. chloroform.

9. **ASPHALT CEMENT,** various mixtures of asphalt with sand, powdered stone, sulphur, oils, litharge, rubber waste &c. Suitable for a variety of purposes.

C. **CASEIN CEMENT.** Freshly prepared cheese is mixed with powdered slaked lime and applied at once. This cement is suitable for articles of wood, metal and glass, but must be used at once. It has therefore been recommended to keep ready a solution of caseine in ammonia, to apply this solution to the parts to be cemented and to add milk of lime when the solution has evaporated,

the pieces being then well pressed together. Of the numerous receipts for the preparation of caseine cements the following should be noted:— According to A. Wenck the caseine to be used is rendered slightly alkaline with sodium or potassium hydroxide, then subjected to a temperature of 60° C. for 24 hours, mixed with lime and water glass and in order to obtain a more rapid effect then mixed with small quantities of substances containing tannic acid (such as gallotannic acid, catechu or oakbark). An improvement on the German Patent 60156 is aimed at by German Patent 154 289.

D. LINSEEDMEAL CEMENT. 3 pts. linseed meal and 2 pts. rye meal, mixed with water, forms an excellent putty for luting distillation apparatus &c.: used in laboratories and factories.

E. CLAY PUTTY. Clay kneaded with soft grey blotting paper and milk, and mixed with a little common salt and ferrous sulphate.

F. WATERGLASS CEMENT. Prepared from a solution of sodium silicate (33° B \acute{e} .) and whitening. Antimony sulphide and zinc dust are frequently added.

For further information see "GLUES", "DEXTRIN" and "GUMS". The following are a few recent patents connected with improvements in adhesives:—

According to German Patent 145 916 the adhesive substance is extracted from seaweed in the form of insoluble calcium tangate, by precipitating a solution of seaweed in Na_2CO_3 by means of milk of lime. The precipitate separated by filtration is dried, mixed with 20 % dry Na_2CO_3 and the mixture used as an adhesive in the form of a powder. From the remainder after filtering, the Na_2CO_3 is regained by means of a current of CO_2 , the resulting solution being used for treating a further quantity of sea weed.

According to German Patent 14 946, the waste liquors from the sulphite industry are used for the preparation of an adhesive, after the sulphite waste is purified, freed from sulphites by oxidation and then heated under pressure with chlorates until the tannic acid is converted into gallic acid and sugar. The mixture is then further heated, the excess of acid neutralized if necessary and the whole mixed while hot with a solution of 10—30 % of glue and evaporated.

According to German Patent 149 550 solid adhesives are made by mixing powdered dextrine, gum arabic or similar adhesives with powdered sugar or soap in a dry condition, and compressing the mixture. By moistening a portion of the surface with a brush a sufficient supply of adhesive is obtained.

The English Patent 885 (1903) treats of the preparation of an adhesive from starch, by subjecting it first to the action of calcium chloride, and then to that of sodium bicarbonate. The starch is then said to be soluble in water and to form a gumlike solution with boiling H_2O . At the general meeting of the "Stärkeinteressenten", Berlin 1904, a communication was made concerning a practicable method of making an adhesive from starch which provides a substitute for a soluble gum. According to the communication starch is treated with 80 % H_2SO_4 at temperatures below 35° C.. When sugar can be detected, the process is interrupted, the whole neutralized with CaCO_3 , the adhesive extracted with some solvent and purified. It is said to be colourless, without smell, easily soluble and of strong adhesive power. See also the article on STARCH. According to German Patent 172 610 an adhesive is obtained as a by-product in the preparation of wheat starch; this is dried and finely powdered and treated with SO_2 . An adhesive material is thus obtained which when mixed with the proper amount of water can be applied with a brush.

Adipic acid $\text{CO}_2\text{H} \cdot (\text{CH}_2)_4 \cdot \text{COOH}$. Prepared by the oxidation of fats with nitric acid. Forms colourless crystals, M. P. 148° , soluble in water, alcohol and ether.

Adjective Dyestuffs see SUBSTANTIVE DYESTUFFS.

Adorin. A powder containing a polymeric form of formaldehyde used in cases of excessive perspiration of the feet.

Adrenaline known also as SUPRARENINE $\text{C}_9\text{H}_{13}\text{NO}_3$. The constitution is probably $\text{C}_6\text{H}_3(\text{OH})_2 \cdot \text{CH}(\text{OH}) \cdot \text{CH}_2 \cdot \text{NH} \cdot \text{CH}_3$. It is the active principle of the suprarenal bodies. For its preparation the external layers of the suprarenal glands are used. These are extracted with water or dilute acids, the extract concentrated and the residual product purified by recrystallization.

Bertrand prepares the substance by taking the suprarenal glands of the horse in a fresh condition, reducing them to a fine state of subdivision, mixing with powdered oxalic acid and then macerating with 95 % alcohol. The whole is then squeezed and the expressed liquor filtered and evaporated to remove the alcohol. The lecithin which separates is removed by shaking with petroleum ether, and the aqueous layer is purified by centrifuging after treatment with lead acetate. The adrenaline is obtained in a crystalline state by the evaporation (*in vacuo*) of the clear yellowish fluid and the subsequent addition of a little ammonia. The product is further purified by successive treatments with sulphuric acid, alcohol and ammonia.

From 118 kilos of the fresh tissue 125 g of adrenalin are obtained.

According to the later method of Stolz, it may be prepared by the action of chloracetyl ethylchloride on catechol.

Pure adrenaline is a grey-white crystalline powder insoluble in water. M. P. 212° . It is sold in this form and also as adrenaline hydrochloride and as suprenine borate.

By reason of its strong astyptic properties it is used for the staunching of wounds and also in cases of catarrh. The strength of solution employed varies from 0.1 to 0.01 %. The maximum quantity used as a subcutaneous injection is 0.0005 g.

Adurol see PHOTOGRAPHIC CHEMICALS.

Agaricine. A resin acid obtained by extraction with alcohol of the fruit-bodies of *Polyporus officinalis* and of *Agaricus albus*. In a pure state it forms powdery crystals with a silky lustre, slightly soluble in cold water, ether and chloroform, but readily in boiling water or alcohol and most readily in hot acetic acid.

It is used medicinally as a febrifuge in doses of from 0.005 to 0.01 g.

Agathine (SALICYLALDEHYDEMETHYLPHENYLHYDRAZONE). Obtained by the action of molecular quantities of salicylic aldehyde and *as*-methylphenyl hydrazine. White crystals insoluble in water, soluble in alcohol, ether and benzene. M. P. 74° . Used medicinally as an antineuralgic in doses from 0.15 to 0.5 g.

Agurine (THEOBROMINESODIUM ACETATE). Is recommended as a good diuretic and is prescribed in doses of from 0.5 to 1 g with a maximum daily dose of 3 g.

Air, atmospheric. A mechanical mixture of 23.2 % oxygen, 75.5 % nitrogen and 1.3 % argon (by weight), together with carbon dioxide and other gases. At latitude 45° 1 litre of dry air at 760 mm and 0° weighs 1.29306 g. Reckoning water as unit the S. G. is 0.0012934. At a temperature t and pressure b the S. G. (D) of air is given by the formula

$$D = \frac{0.0012934 \cdot b}{(1 + 0.003665 \cdot t) \cdot 760}$$

Calculated for water at 4° at temp. t and press. b.

t	b = 720 mm	730 mm	740 mm	750 mm	760 mm	770 mm
0°	0,001225	0,001242	0,001259	0,001276	0,001293	0,001310
1°	0,001221	0,001238	0,001255	0,001272	0,001289	0,001306
2°	0,001216	0,001233	0,001250	0,001267	0,001284	0,001301
3°	0,001212	0,001229	0,001246	0,001262	0,001279	0,001296
4°	0,001208	0,001224	0,001241	0,001258	0,001275	0,001291
5°	0,001203	0,001220	0,001237	0,001253	0,001270	0,001287
6°	0,001199	0,001216	0,001232	0,001249	0,001266	0,001282
7°	0,001195	0,001211	0,001228	0,001244	0,001261	0,001278
8°	0,001190	0,001207	0,001223	0,001240	0,001257	0,001273
9°	0,001186	0,001203	0,001219	0,001236	0,001252	0,001269
10°	0,001182	0,001198	0,001215	0,001231	0,001248	0,001264
11°	0,001178	0,001194	0,001211	0,001227	0,001243	0,001260
12°	0,001174	0,001190	0,001206	0,001223	0,001239	0,001255
13°	0,001170	0,001186	0,001202	0,001218	0,001235	0,001251
14°	0,001165	0,001182	0,001198	0,001214	0,001230	0,001246
15°	0,001161	0,001178	0,001194	0,001210	0,001226	0,001242
16°	0,001157	0,001174	0,001190	0,001206	0,001222	0,001238
17°	0,001153	0,001169	0,001185	0,001201	0,001218	0,001234
18°	0,001149	0,001165	0,001181	0,001197	0,001213	0,001229
19°	0,001146	0,001161	0,001177	0,001193	0,001209	0,001225
20°	0,001142	0,001157	0,001173	0,001189	0,001205	0,001221
21°	0,001138	0,001154	0,001169	0,001185	0,001201	0,001217
22°	0,001134	0,001150	0,001165	0,001181	0,001197	0,001213
23°	0,001130	0,001146	0,001161	0,001177	0,001193	0,001209
24°	0,001126	0,001142	0,001158	0,001173	0,001189	0,001204
25°	0,001122	0,001138	0,001154	0,001169	0,001185	0,001200
26°	0,001119	0,001134	0,001150	0,001165	0,001181	0,001196 •
27°	0,001115	0,001130	0,001146	0,001161	0,001177	0,001192
28°	0,001111	0,001127	0,001142	0,001158	0,001173	0,001188
29°	0,001108	0,001123	0,001138	0,001154	0,001169	0,001184
30°	0,001104	0,001119	0,001135	0,001150	0,001165	0,001181

Air compressors.

Harzer & Co., Finsbury Pavement House, London E.C.

Air pumps.

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advta.).

Paul Passburg, 30 Great St. Helen's, London E.C.

J. Scott & Son Ltd., 2 Talbot Court, London E.C.

Folkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Vogelin & Huebner A.-G., Halle a. S., Germany.

Air, liquid. The critical temperature of atmospheric air is -140° , the critical pressure is 39 atmospheres. Under ordinary atmospheric pressure air becomes liquid at -191° .

Liquid air is usually prepared by the help of the Linde apparatus. The air is compressed by a two-cylinder pump first under a pressure of 16 and then further under one of 200 atmospheres, led into a cooling chamber to get rid of the heat developed by the compression and then passed through a series of copper tubes, running inside one another and spirally arranged. The air passes along the inner tube to the bottom, escapes through a reducing valve where the pressure is reduced from 200 to 16 atmospheres, thence through the outer copper tube back to the compression chamber when it is ready to re-enter the cycle. The expansion taking place at the valve causes absorption of heat which constantly cools the escaping air and so

Blücher.

also the air passing down the inner tube until eventually liquefaction takes place. The liquid air is collected in suitable vessels and a fresh quantity of air is admitted to replace that lost by liquefaction. In order to prevent the apparatus from being choked by ice the entering air must be carefully dried by passing through absorption apparatus. The liquid air thus obtained is rendered cloudy by the presence of solid CO_2 , which may be removed by filtration. Liquid air is a water-clear, bluish liquid which does not fume in the air.

Pictet's method for the liquefaction of air depends upon thermo-mechanical principles. It is protected by French Patents 322 600 and 324 715, the most important points being the following. 1. The air is filtered, compressed and dried. 2. The dry compressed air is cooled to its liquefying point i. e. about -194° . 3. The liquid air is filtered to remove solid CO_2 . 4. The filtered liquid is again allowed to evaporate in order that the more volatile constituent i. e. nitrogen and afterwards the less volatile constituent i. e. oxygen may escape. 5. The cold due to this evaporation is used to liquefy compressed air pumped into the apparatus. 6. An automatic arrangement secures continuous working. 7. Another automatic arrangement allows the O and N to escape of the required degree of purity and also prevents the escape of a gas mixture too nearly approaching in composition that of ordinary air.

In the Pictet method a portion of the energy, viz. that set free during the re-evaporation, is used for the production of mechanical force ($\frac{1}{4}$ to $\frac{1}{3}$ of the energy of the system is thus rendered available).

German Patent 162 323 (Pictet) protects an apparatus for the separation of the constituents of air in which by means of compressed air a continuous fractional distillation of liquid air takes place. Other patents taken out by Pictet are German Patent 162 702 and 169 564. In spite of all improvements in the Pictet method, the Linde apparatus seems to be the best.

For storing liquid air, Dewar vessels are used. These are double-walled, the space between the two walls being rendered as vacuum as possible; the inner surfaces are also covered with a highly lustrous silver mirror. In this way conduction and radiation of heat are much diminished.

If liquid air is allowed to stand in open vessels it evaporates only gradually, since the evaporation of a portion cools the residue. According to recent investigations, in 24 hours 7 % at most is lost by evaporation if the liquid is contained in Dewar vessels.

German Patent 161 362 protects a vessel for collecting and transporting liquid air which is exactly like the Dewar vessel in so far as it consists of two vessels one hanging inside the other, separated by a vacuum space. The special feature of the apparatus lies in the fact that the outer vessel is enclosed in a sack-shaped covering impenetrable to air, which is continued as an inner lining of the inner vessel with the object of covering the whole with a continuous insulating material.

Liquid air is much richer in oxygen than atmospheric air because the oxygen liquefies at -182.7 while the nitrogen remains gaseous above -194.4° . On standing the liquid air loses N by evaporation, and a mixture of $\frac{2}{3}$ O and $\frac{1}{3}$ N is left. For many purposes this may be used in place of pure O. On account of its high price it has not been largely used, though it is used to some extent as an explosive (oxylignite) mixed with wood charcoal. When this is exploded with a detonator (fulminating mercury) the carbon-oxygen mixture burns with explosive violence. Since the liquid air quickly evaporates the oxylignite cartridges are made of wadding impregnated with three times the weight of wood-charcoal powder and only treated with the liquid air just before use.

Liquid air is sold in Dewar vessels of 2 litres capacity at a price of 1/6 d per litre. The vessels are packed for transport in upholstered baskets. An arrangement for emptying the flasks consists of two glass covers, a rubber stopper and a rubber ball.

Air Gas. A mixture of air and *gasoline* (q. v.) is used for lighting purposes. Usually the air is compressed and forced through the liquid hydrocarbon when it becomes charged with the vapours of the latter. During the preparation of the compressed air-gas no rise of temperature takes place.

Another variety of air-gas is the so-called *aerogene-gas*. This is obtained not by passing air through gasoline or benzine but by mixing the air with the vapours. These vapours are contained in a chamber in which the pressure is reduced. After mixing the gas is compressed. The method is protected by German Patent 150 766. The difference between ordinary air-gas and aerogene-gas is that the latter is always of the same composition and no condensation takes place. The apparatus used in its manufacture consists of a pump worked by clockwork or a motor which sucks in the air and intimately mixes it with the vapour. The amount of air used is measured by a gas-meter of peculiar construction: in the elongated spindle of the drum a suction apparatus is present which introduces the hydrocarbon in the manner described.

Alapurine. A special name given to the purest kinds of lanoline. For further particulars see the article WOOL-FAT.

Alarums. Electric alarums for chemical works are so constructed as to avoid the possibility of explosive gases becoming ignited by any electric sparking. The mechanism is also protected from the influence of moisture. A similar kind of apparatus is made for use in machine- and battery works.

Albargine. A compound of gelatose and silver nitrate obtained by acting with silver nitrate upon gelatose prepared from a dialysed solution of gelatine. The mixture is carefully evaporated to dryness.

A pale yellow powder easily soluble in cold water. Chiefly used in the form of a 0.1 to 0.2 % solution as an injection in cases of gonorrhoea. It is also employed in the treatment of wounds and is then used as a 2 % solution. For convenience it is also prepared in the form of pastilles.

Albumin. For a general account see the article PROTEIDS.

Albumin is technically prepared from the white of hens' eggs (Egg albumin) and from the blood-serum of different animals, particularly from that of cattle (Serum albumin).

Albumin:

W. Eugen Seemann, Stuttgart, Germany.

1. **EGG ALBUMIN.** Fresh white of egg after suitable dilution is beaten into a froth. After the froth has disappeared the solution is filtered through a conical woollen bag and the filtrate spread out in thin layers on plates and flat dishes. It is then evaporated to dryness in a stream of dry air at a temperature of 30° to 40°. This drying takes from 30 to 60 hours and the resulting albumin is left as a pale yellow, transparent mass often occurring in leaves or in a conchoidal form. With water it dissolves to an almost perfectly clear odourless solution.

2. **BLOOD ALBUMIN.** The freshly caught blood is spread out in shallow dishes until the separation into fibrin and the pale yellow serum is complete. The serum is treated in the same way as is the egg albumin except that it is not diluted with water. It is more difficult to prepare this substance in a pure state than is the case with egg albumin. In order to purify blood albumin it is necessary to filter the fresh serum through charcoal, to precipitate the albumin with lead acetate and to decompose the washed precipitate with carbon dioxide. When the decomposition is complete, the whole is allowed to settle, the excess of lead removed by saturation with H_2S and the filtered solution evaporated in the manner described above.

According to German Patent 137 994 and 143 042 a colourless, odourless and tasteless proteid may be prepared from blood serum by treatment with H_2O_2 . The impure proteids are salted out from the serum dissolved in ammonia and the solution treated at the boiling temperature with hydrogen peroxide.

Blood albumin:

W. Eugen Seemann, Stuttgart, Germany

The English Patent 10 227 (1905) protects a method for the preparation of colourless albumin from a solution of either egg- or serum albumin solution. The solution is first treated with hydrosulphites and then with an organic acid such as acetic acid. The product is made neutral by the addition of sodium acetate and then of ammonia and the solution finally evaporated to dryness.

Albumin is used as a mordant in dyeing and calico printing, for the preparation of photographic papers, as a clearing material for cloudy solutions and in the manufacture of gums and other adhesives.

Albumin preparations:

W. Eugen Seemann, Stuttgart, Germany.

Albumin paper see PHOTOGRAPHIC PAPERS.

Alcho. A term used to denote a substance containing aluminium carbonate. It occurs in the form of a white loose powder slowly soluble in cold diluted acids, more quickly on heating with development of carbon dioxide. It is used medicinally and possesses a faint earthy taste.

Alcohol (ETHYL ALCOHOL, SPIRITS OF WINE). The raw materials used in manufacturing spirits are:

1. alcoholic materials, like wine, wine residues, beer etc.;
2. materials containing sugar, like sugar beet, molasses and sweet fruit;
3. materials containing starch, like potatoes and corn.

When alcoholic material is used spirits are produced by distillation, while for materials containing sugar the sugar must be converted into alcohol by fermentation before distillation. When the raw material is starch it must be first converted into sugar (generally by diastase, more rarely by boiling with dilute acids), the sugar is then fermented and the alcohol separated by distillation. The preparation of alcohol from starchy materials will be described; this includes the details of the manufacture from sugar and alcoholic materials; slight differences in the processes will be considered at the end of the article.

In the preparation from potatoes the latter are carefully washed in special potato-cleaning machines and then steamed until soft so as to obtain the starch in a form which lends itself readily to conversion into sugar. This is usually carried out in the so-called Henze-apparatus, shaped like an inverted cone. The potatoes are boiled with steam at a pressure of 2—3 atmospheres and are then pressed — also by steam — through a sharp grid into the mashing can. The potatoes are not yet sufficiently crushed, they are ground further either by a kind of shredding machine in the mashing pan or by a mill acting between the Henze-steamer and the mashing pan. The malt (q. v.), already crushed, has been, as a rule, added previously so that during the process of crushing the potatoes they become well mixed with it. The diastase of the malt causes the conversion of the potato-starch into sugar in about half an hour; the most favourable temperature is 55°. Formerly a temperature of 65° had to be applied so as to kill the bacteria always present which were detrimental to the process of fermentation; this end is now better and more conveniently attained by adding a little hydro fluoric acid or sodium fluoride. The fermented mash is cooled by water and air to 15—20°, and artificial yeast (see YEAST)

is added. This converts the sugar into alcohol (the fermenting vats are of pine or oak). As in Germany the manufacturer of alcohol is taxed according to the size of the mashing room it is customary there to mash very thickly (20—26° Ball.). The temperature during fermentation rises about 17°; before the beginning it should not be above 14° as a temperature of more than 31° hinders the fermentation. Fermentation takes place in three phases (preliminary-, chief- and post-fermentation); a distinction is made between rising, falling and rolling fermentation. 1 kg starch flour yields theoretically 71.6 literpercent alcohol¹⁾; in practice the output is 48—63 literpercent.

For the quick refractometric method of determination of alcohol in potato-mash see Dr. A. Frank-Kamenetsky.

Carl Zeiß, Jena (Germany) Prosp. Moss. 160.

In the manufacture of alcohol from grain the largest output is obtained with maize. Barley, rice and oats are much used while rye is of less importance. Grain spirits are mostly produced as products in making yeast (see YEAST). Maize is boiled unground in Henze steamers fitted with stirrers, then steamed under higher pressure and finally blown through a sharp grid valve into the mashing pan; the other kinds of grain are treated similarly.

The conversion of starch into sugar by dilute acids is used in Southern districts where the production of malt is difficult.

The alcohol must be obtained from the fermented mash by distillation. It contains 8—13 % by vol. of ethyl alcohol and more or less amyl alcohol, propyl alcohol, butyl alcohol etc. When the mash is distilled in a simple distilling apparatus (consisting of bulb, condenser and receiver) the product contains less than 40 % alcohol, a higher percentage being obtained by subsequent rectification. The forms of apparatus now used however produce 75—95 vol. % alcohol in a single operation. A number of these machines work continuously, i. e. the alcohol leaves the apparatus on one side, the spent mash on the other and fresh quantities of fermented mash are introduced. In using automatic apparatus the mash enters continuously, regulated automatically by the progress of distillation. A scale indicates whether the amount of mash entering is correct; at the same time the quality of the alcohol is controlled by an alcoholometer and thermometer while a part of the out-running mash is distilled in a testing apparatus which indicates by an alcoholometer the slightest traces of alcohol possibly still present. The principle of a new rectification apparatus, also suitable for alcohol, is protected by Germ. Pat. 140824, described in the article BENZENE.

Crude alcohol besides 75—95 % by volume of ethyl-alcohol and water contains other alcohols, and also furfural, acetal, acetic ether etc.; of these amyl alcohol together with propyl alcohol and butyl alcohol and the esters of acetic acid, caproic and capric acid are called fusel oil (q. v.). They are removed by a process of refining the crude spirit. This is usually done in special works, where the crude spirit is filtered through charcoal to remove the fusel oils and is then very carefully rectified. The product is spirits of wine and fine spirit (96 vol. % alcohol, prime spirit (94—96 vol. %) second spirit (90—92 vol. %) while the other fractions are used for other purposes or are rectified again with a fresh portion of crude spirit. When drinkable spirits are made the raw material is only filtered as rectification removes the desired aromatic ingredients.

Other methods of refining the crude alcohol, such as treatment with soda, lime, bleaching powder, permanganate etc. are of less importance. By repeatedly shaking spirits with fatty oils they can be entirely freed from fusel oils.

¹⁾ Literpercent alcohol is the product of the number of liters and the volume-percentage of the spirits.

ILGES has constructed a special automatic apparatus which renders possible the direct production from the mash of fine spirit free from fusel oil.

Materials containing sugar which are used in the manufacture of alcohol are 1. beet (sugar beet), 2. molasses, and 3. sweet fruit. Beet root is comparatively little used. Fermentation of raw beet sugar necessitates its inversion; either the pulp or better still the juice of the beet is fermented. In the latter case the beet slices (see "SUGAR") are treated with warm acidulated water and the juice fermented by yeast or fermenting beet juice. Molasses (q. v) are rarely used now since methods of extracting the sugar have been discovered. It is diluted with 3—4 times the amount of water and then accurately neutralised or slightly acidified with acids; fermentation is effected by artificial yeast. Sweet fruit, like cherries, plums etc. are only used on a minor scale; they are squashed, the juice left to ferment of itself and then distilled.

Concerning the use of the residues see "DISTILLER'S WASH" and "FEEDING STUFF".

Attempts to obtain alcohol from wood have lately become important. The process given by CLASSEN and protected by Germ. Pat. 111868, 118540 121869, 123911 and 130980 is likely to become of practical value. The wood is used in the form of sawdust. It is treated with $\text{SO}_2 + \text{H}_2\text{SO}_4$ or with SO_2 only, or the moist sawdust is subjected to the action of vapours of sulphuric anhydride. The inversion to dextrose is carried out in rotating cylinders lined with lead; the inversion is more rapid when the cylinders are previously heated to 30—40° C. The process was then improved by adding more moisture to the sawdust and heating the reaction product obtained with SO_2 in closed vessels to 125—135° C. The most recent of the patents enumerated uses aqueous sulphurous acid to moisten the sawdust. 100 kg wood (with 25—30 % moisture) are mixed with 30—35 kg aqueous sulphurous acid (9 % anhydride) and the whole (which has a moist appearance) is heated (with stirring) to 120—145° C. in digestors. After 60 minutes the free SO_2 is blown off and the remainder boiled with H_2O when the last traces of sulphurous acid disappear. After neutralisation the liquid is ready for fermentation which is said to take place as smoothly as if a pure solution of dextrose were under treatment. According to the patent 25 % of the wood is extracted and 90 % of this is capable of fermentation. As the alcohol produced has a more agreeable taste and smell than that obtained by the old method this new process appears to possess various advantages. CLASSEN has now added another patent 161644 to the others. It is based upon the fact that woods containing tannic acid yield solutions which do not ferment well. The substance hindering the fermentation is gallic acid, and this should be separated as an insoluble metallic compound before beginning the process of fermentation. — The *Lignum Inversion Co.*, Chicago, in applying CLASSEN's method uses 3 % sulphurous acid and heats with steam under a pressure of 7 atmospheres to 165° C. 100 kg wood give about 12 litres pure alcohol.

The process of obtaining alcohol from sawdust due to SIMONSON, Christiania, which he described at the V. International Congress for applied Chemistry, Berlin 1903, is similar to that of CLASSEN: The wood is treated with dilute H_2SO_4 under pressure and the sugar obtained is fermented. About 25 % sugar is produced and in the most successful experiments 78 % of this was fermented.

Other patents dealing with the production of alcohol from wood are Russian Pat. 6319 (1902) and Amer. Pat. 745675.

According to the Eng. Pat. 21824 (1901) alcohol is produced from faeces by subjecting them to dry distillation absorbing the gases arising in H_2O and distilling the mixture obtained; the residues from the last distillation may be used to absorb the gases. — DORNIG and PRAETORIUS have made practical experiments with the process which have proved the observations false and the process hopeless.

Attempts to produce alcohol synthetically are increasing in number. According to Germ. Pat. 149893 ozone is allowed to act on a mixture of acetylene and hydrogen at a low temperature. The proportions are 4 vol. H to 1 vol. C_2H_2 , this mixture being brought together with excess of ozone in specially cooled apparatus.

The out flow of dried gases is regulated in such a way that only pure oxygen escapes. This reaction is said to produce alcohol easily, rapidly and to give a good yield.

Another method for the synthetic production of alcohol is that of ARACHE-QUENNE; a mixture of metallic oxides which is kept secret, is heated in electric furnaces with powdered coke; a carbide, called ethylogene, is formed which gives ethylene when treated with H_2O , (as acetylene is formed from CaC_2). The exhausted residue is dried, mixed with coke and replaced in the electric furnace to produce more ethylogene. The ethylene gas is collected in a gasometer and then pressed through H_2SO_4 forming ethyl-sulphuric acid; the latter when treated with H_2O gives alcohol. Theoretically 50—53 kg coke are necessary to produce 1 hl alcohol; in practice at present 200 kg coke are required.

Fine spirit is not absolute alcohol; in order to obtain the latter the spirit has to be treated with dehydrating agents like calcium chloride or quicklime and then be redistilled.

Germ. Pat. 142502 is interesting; it deals with the production of absolute alcohol by adding benzene to the alcohol and fractionally distilling. The process is based upon the fact that a mixture of alcohol, water and benzene passes over in a constant proportion and boils at a lower temperature than any one of the constituents of the mixture; another observation made was that a mixture of alcohol and benzene also passes over in a constant ratio and boils at a lower temperature than either of the constituents, though at a higher temperature than required for a mixture of these two substances with water. When therefore a mixture of these three substances, say 90—99 % alcohol with benzene is subjected to distillation the first to pass at the lowest temperature is a mixture of alcohol, benzene and water until all the water has disappeared. Then follows the mixture of alcohol and benzene until all the latter has passed over. The residue is now pure alcohol, free from water or benzene, which is then redistilled. One operation therefore suffices to reach absolute alcohol from common spirits. In stead of benzene, chloroform, carbon tetrachloride, carbon disulphide, benzine and other liquids of comparatively low boiling point may be used. —

A new product is alcohol for lighting purposes. It is prepared according to Germ. Pat. 156988 by mixing about 70—95 vol. of 90 % alcohol with 5—30 vol. of purified benzene oil boiling at 160—180° C. This spirit burns in a lamp with a wick and gives a bright flame depositing no soot. No incandescent mantle is used. Nevertheless it will hardly be able to compete with petroleum, although it is considerably cheaper and less dangerous than common alcohol. The disagreeable smell of benzene is covered by adding about 2 % methyl alcohol.

Absolute alcohol is a clear colourless liquid, of agreeable smell and sharp burning taste. S. G. (at 0° C.) 0.80625, at 15° C = 0.79367. It absorbs water from the air and from organic and inorganic substances. A contraction in volume occurs when it is mixed with H_2O .

The following table by TRALLES gives the S. G. and the contents in vol. % of aqueous alcohol at 15.56° C.

TRALLES areometer indicates the vol. % directly. A spirit of 70 % Trall. contains 70 vol. % absolute alcohol in 100 parts of liquid at the standard temperature of 15.56° C. From the vol. percent the weight percent is calculated by dividing the S. G. of the spirit under investigation by the S. G. of absolute alcohol (0.7937) and multiplying the quotient by the vol. % contents.

Alcohol vol. %	S. G.	Alcohol vol. %	S. G.	Alcohol vol. %	S. G.	Alcohol vol. %	S. G.
1	0.9976	26	0.9698	51	0.9315	76	0.8739
2	9961	27	9679	52	9295	77	8712
3	9947	28	9668	53	9255	78	8685
4	9933	29	9657	54	9254	79	8658
5	9919	30	9646	55	9234	80	8631
6	9906	31	9634	56	9213	81	8603
7	9893	32	9622	57	9192	82	8575
8	9881	33	9609	58	9170	83	8547
9	9869	34	9596	59	9148	84	8518
10	9857	35	9583	60	9126	85	8488
11	9845	36	9570	61	9104	86	8458
12	9834	37	9559	62	9082	87	8428
13	9823	38	9541	63	9059	88	8397
14	9812	39	9526	64	9036	89	8365
15	9802	40	9510	65	9013	90	8332
16	9791	41	9494	66	8989	91	8299
17	9781	42	9478	67	8965	92	8265
18	9771	43	9461	68	8941	93	8230
19	9761	44	9444	69	8917	94	8194
20	9751	45	9427	70	8892	95	8157
21	9741	46	9409	71	8867	96	8118
22	9731	47	9391	72	8842	97	8077
23	9720	48	9373	73	8817	98	8034
24	9710	49	9354	74	8791	99	7988
25	9700	50	9335	75	8765	100	7937

• Apart from its use as a beverage alcohol is largely used as a solvent, in the manufacture of chloroform, chloral, iodoform, etc. etc., as fuel and for lighting (incandescent spirit light). See also "ALCOHOL-HYDROCARBON-GAS".

On the denaturing of alcohol see "DENATURING". According to Germ. Pat. 139387 denatured alcohol is produced directly from sugar-containing mash by means of alcoholic and amyl-alcoholic fermentation. It is advantageous to begin with the amyl-alcoholic fermentation the most favourable temperature being 35—40° C.; microbes found in waters containing lime are used, CaCO₃ being added during the process to neutralise the volatile fatty acids formed. After the amyl-alcoholic fermentation the substance is cooled to 24° C. and yeast added in the usual manner. When this fermentation is complete the mash is distilled until exhausted producing 90 vol. % alcohol which can replace petroleum in its various applications. — The process is probably not profitable.

Country and Name of alcohol	S. G. at 15° C.	Methy- lene and its impuri- ties %	Pyridine or Pyri- dine bases %	Acetone %	Ben- zene %	Ben- zene (impure) %
France	0.832	7.5	—	2.5	—	0.5
Germany (denat.)	0.819	1.5	0.5	0.5	—	—
" (motor sp.)	0.825	0.75	0.25	0.25	2.0	—
Austria (denat.)	0.835	3.75	0.5	1.25	—	—
" (motor sp.)	0.826	0.5	trace	trace	2.5	—
Russia	0.836	10.0	0.5	5.0	—	—
Italy (motor sp.)	0.835	6.5	0.65	2.0	1.0	—
Switzerland	0.837	5.0	0.32	2.2	—	—

The following table, taken from the "Zeitschr. d. Vereins deutsch. Ing.," contains information on the means used for denaturing spirits in various

countries; the figures are partly the results of chemical analyses as the processes used are kept secret in many countries.

Test: The amount of pure alcohol is determined by the spec. gravity. (See the table given above). Free acids are determined by titration with alcoholic N or $\frac{N}{20}$ potassium hydroxide using phenolphthalein as indicator. To test for aldehyde 100 cc are distilled off from 500 cc and an aqueous solution of m-phenylene diamine hydrochloride is poured into the distillate; a yellowish red layer forming between the two liquids in 2 to 4 minutes indicates the presence of aldehyde. Furfural is tested for by adding 10 drops aniline and 2 drops HCl to 10 cc spirit: In the presence of furfural the mixture turns pink. Easily oxidizing substances (aldehyde, furfural etc.) are tested by BARDET's permanganate method: 50 cc of the alcohol brought to 95 vol. % is mixed with 1 cc of a 0.02 % solution of KMnO_4 . The time required for decolorization varies according to the amount and nature of the impurities. According to the Swiss alcohol regulations, alcohol (for beverages) which is decolorized in less than 30 minutes and prime spirit which is decolorized in less than 15 minutes are to be rejected; fine spirits decolorizing in less than one minute are to be regarded as unsatisfactory.

In testing for fusel oil the greater part of the spirit is evaporated at a low temperature, and the remaining liquid shaken with an equal volume of ether. When the ether solution is evaporated the fusel oil remains and is recognised by its smell.

The fusel oil is determined by means of the RÖSE-HERZFELD-WINDISCH apparatus: By means of the S. G. the alcohol is determined accurately, than the spirit is brought to a concentration of 30 vol. % alcohol according to

the following formula $X = \frac{10v - 300}{3}$ where v is the volume percent, and

x the number of cc H_2O to be added for each 100 cc alcohol; after diluting the S. G. must be again determined and if necessary corrected by adding alcohol or water until the S. G. at 15°C . is 0.96564. The shaking apparatus is filled with the purest chloroform at 15°C . to the mark 20; then 100 cc of the 30 vol. % spirit and 1 cc H_2SO_4 (S. G. 1.2857) are added, the apparatus closed shaken round well 150 times. It is then placed in water at 15° and made to float in a vertical position. The increase in height (at 15°) after the CHCl_3 has settled is read. The amount of fusel oil contained is then found by the following table based on observations made by the Imperial German Health Office.

Rise cm	Fusel- oil Vol. %	Rise ccm	Fusel- oil Vol. %	Rise ccm	Fusel- oil Vol. %	Rise ccm	Fusel- oil Vol. %	Rise ccm	Fusel- oil Vol. %	Rise ccm	Fusel- oil Vol. %
0.01	0.0066	0.12	0.0796	0.23	0.1525	0.34	0.2255	0.45	0.2984	0.56	0.3713
0.02	0.0133	0.13	0.0862	0.24	0.1591	0.35	0.2321	0.46	0.3050	0.57	0.3780
0.03	0.0199	0.14	0.0928	0.25	0.1658	0.36	0.2387	0.47	0.3117	0.58	0.3846
0.04	0.0265	0.15	0.0996	0.26	0.1724	0.37	0.2455	0.48	0.3183	0.59	0.3912
0.05	0.0332	0.16	0.1061	0.27	0.1790	0.38	0.2520	0.49	0.3249	0.60	0.3979
0.06	0.0398	0.17	0.1127	0.28	0.1857	0.39	0.2586	0.50	0.3316	0.61	0.4045
0.07	0.0464	0.18	0.1194	0.29	0.1923	0.40	0.2652	0.51	0.3382	0.62	0.4111
0.08	0.0531	0.19	0.1260	0.30	0.1989	0.41	0.2719	0.52	0.3448	0.63	0.4168
0.09	0.0597	0.20	0.1326	0.31	0.2055	0.42	0.2785	0.53	0.3514	0.64	0.4244
0.10	0.0663	0.21	0.1393	0.32	0.2122	0.43	0.2851	0.54	0.3581	0.65	0.4310
0.11	0.0729	0.22	0.1459	0.33	0.2188	0.44	0.2918	0.55	0.3647	0.66	0.4377

Spirit Rectifying and Distilling apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Denaturing preparations for spirits:

Hugo Blank, Berlin W. 35.

Alcohol-hydrocarbon gas. A new gas for lighting and motive purposes which is obtained from alcohol and hydrocarbons; it represents a new use for spirits which are being produced in quantity exceeding the demand. The alcohol-hydrocarbon gas which was introduced by F. PAMPE requires only very simple apparatus for its production.

Of the two raised reservoirs one contains spirits of about 10—75 % (by weight) the other petroleum or brown-coal oil or some other mixture of hydrocarbons. Both liquids flow together out of the reservoirs into a retort down the walls of which they trickle. In this way the liquids are warmed in the upper portion of the retort and are volatilized when they reach the bottom. They then pass into the retort previously heated to a red heat, where the actual vapourization takes place. In the usual procedure the volatilization takes place leaving no residue.

The Germ. Pat. 144371 taken out by the inventor Fr. PAMPE protects a process for producing lighting- and heating gas by the joint evaporation and volatilization of different commercial products consisting of sparingly miscible or non-miscible combustible liquids especially of dilute alcohol (60 to 90 %) and petroleum. The construction of the retorts is also described in the patent.

Alcohol-hydrocarbon gas has a S. G. of 0.7 and contains 25 % or more of heavy hydrocarbons, 20 % CO, 25—30 % H and 20—27 % CH₄. The great purity of the crude gas makes purifying practically superfluous. It is calculated that 1 cb. met. of the gas costs about 2½ d, 100 candle power per hour using an argand burner costs 1 d; in a two-hole burner ¾ d, in an incandescent burner ¼ d. This gas may perhaps prove of use for small installations.

The heating and lighting gas, which is protected by the Germ. Pat. 141066 and 146120, is probably similar to this. Alcohol is decomposed, in this process by red hot coal in a water gas generator.

Alcoholic Beverages. Spirits are generally obtained by diluting alcohol with water so that the resulting product contains 25—45 % of alcohol. The different beverages are classed according to the original substance from which the alcohol is made into whisky, malt spirits, potato brandy, cherry brandy, plum brandy and French brandy distilled from the grape. These brandies are prepared by distillation over fruit as is the case with cherry brandy &c. or by the addition of sugar and essential oils to the alcohol. The different varieties again are mixed with characteristic substances, such as oenanthylic ether &c.

The term arrac is a collective name for a class of beverages made in the tropics by fermentation of rice and the cocoa nut palm. The material is made into a mash, fermented and then distilled, after which it is rectified once or twice.

The alcoholic contents of genuine arrac usually vary between 48 and 54 % (by weight). Rum is made from the molasses of cane sugar, by diluting with water, fermenting, distilling and finally rectifying the product which then contains between 65 and 73 % (by weight) of alcohol. Cognac or genuine French brandy is obtained by the distillation of wine. The product acquires the characteristics peculiar to this beverage only after being stored for a considerable time in oak barrels. The contents of alcohol vary from 40 to 60 % (by weight).

Arrac, rum and brandy are often artificially prepared. Liqueurs and bitters are usually mixtures of alcohol and water with sugar, essential oils, vegetable extracts, essences etc. The contents of alcohol vary between 20 and 60 %. The method of preparation is most varied and the number of different kinds is very great. The so-called *crèmes* have the largest percentage of sugar.

All spirits must be stored for a considerable time before they reach their prime. Various methods have been proposed for hastening the process of

maturing, the best of which seems to be the treatment with ozone. Apparatus for the production of ozone for the artificial ripening of spirits and wines have been devised and equipped by SIEMENS AND HALSKE.

The colour of spirits is improved by the addition of a solution of carmine, tincture of whortleberries and raspberry colouring for red; aqueous solution of indigo carmine for blue; mixtures of the above for violet; curcuma, (turmeric) for yellow; chlorophyll for green and burnt sugar for brown.

Further details on the manufacture of spirituous beverages will be found under ALCOHOL.

Aldehyde. Organic compounds containing the group $H - C = O$. They resemble the ketones in that they possess the carbonyl group CO .

The aldehydes may be regarded as intermediate products in the oxidation of alcohols to acids. They may be prepared by the oxidation of alcohols or by the distillation of calcium formate with the calcium salt of a monobasic fatty acid.

The most important aldehyde is acetaldehyde, $CH_3 \cdot CHO$ known simply as aldehyde. For its preparation a mixture of 3 parts 90 % alcohol and 4 parts conc. H_2SO_4 are poured with constant cooling into a solution of three parts of potassium bichromate in 12 parts of water. This mixture is then slowly heated on the water bath and the vapours condensed. The distillate consists of a mixture of aldehyde, alcohol and acetal. This distillate is warmed to 50° and the vapours conducted into cold ether. Into the ethereal solution ammonia is led and a crystalline precipitate of the aldehyde ammonia forms which is separated, drained, and then decomposed by distillation with dilute H_2SO_4 .

Technically it is prepared from the first runnings in the distillation of spirits and is separated from these by fractionation.

The method described by the French Pat. 329522 is of interest. According to this halogen substitution products of fatty and aromatic compounds are converted into aldehydes by the action of the derivatives of the alkali metals of formaldehyde. For example, ethyl chloride treated with the theoretical amount of the sodium derivative of formaldehyde gives acetaldehyde and $NaCl$.

Aldehyde is a colourless, mobile, very inflammable liquid. S. G. 0.801 (at 0°) B. P. 20° . 8. Mixes with water, alcohol and ether, and is readily converted by oxidation into acetic acid. Under the influence of traces of different substances aldehyde passes into a polymeric form, paraldehyde, which is used in medicine.

Aldehyde is used in various synthetic processes, and also for the silvering of mirrors. It was formerly employed in the manufacture of the dyestuff aldehyde green, now no longer used.

Other aldehydes of importance are:— benzaldehyde, chloral, formaldehyde, oenanthylic aldehyde and acrolein. The last-named is described under GLYCERINE, the others under the respective articles.

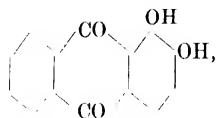
Alcol. (OXYBUTYRIC ACID.) $CH_3 \cdot CH(OH) \cdot CH_2 \cdot COH$. This compound results from the action of cold hydrochloric acid upon aldehyde, the reaction being one of condensation. It is a thick, colourless, odourless fluid, miscible with water and alcohol. B. P. $90-105^\circ$, decomposing at 135° . It has been recommended as an hypnotic.

Alurometer see FLUOR.

Allenide see NICKEL ALLOYS.

Alformine. A name given to a solution of aluminium subformate, $Al(OH)(HCOO)_2$. Strongly acid clear fluid, S. G. 1.108 at 15° contains 15—16 % of dry material. The solution should possess 3—4 times the astringent and disinfectant power of the officinal aluminium subacetate.

Alizarin (MADDER) is 1,2-Dioxyanthraquinone



occurs in the madder root (see also under VEGETABLE DYES). It is manufactured technically almost exclusively by melting anthraquinonemonosulphonic acid and caustic alkali. The different phases in the manufacture are

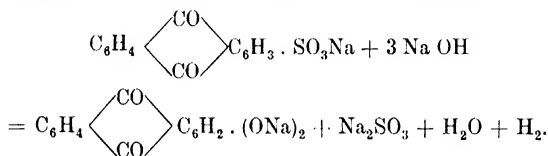
I. Oxydation of anthracene to anthraquinone (with reference to this see article on ANTHRAQUINONE).

II. Converting anthraquinone into the monosulphonic acid.

III. Fusion of the monosulphonic acid with potash.

For the manufacture of anthraquinonemonosulphonic acid, equal weights of anthraquinone and sulphuric acid (the latter containing also 40—50 % SO_3) are gradually heated to 160° in an enamelled vessel fitted with a stirring arrangement. The mass is then allowed to flow into boiling water, in which the monosulphonic acid, which has been formed, dissolves. The liquid is forced through a filter press to remove the unaltered anthraquinone. The filtrate is neutralized with sodium hydroxide and on cooling the sodium salt of anthraquinonemonosulphonic acid crystallizes out almost quantitatively. (The rest is obtained by evaporation.) The new French Pat. 332709 and 333144 treat of the addition of mercury in this process by which sulpho-acids are obtained which do not contain the SO_3H group in m-position (relative to the ketone-group), but only in the o-position.

Anthraquinonesulphonic acid is then converted into Alizarin by fusing it with caustic soda. The reaction corresponds to the equation



Formerly the fusion was carried out in open vessels by which the oxygen of the air brought about the oxidation (i. e. the conversion of the nascent H into H_2O) but now it is usually carried out under pressure in autoclaves — KClO_3 being added as an oxidizing agent. The mixture, with which the autoclaves are filled, consists of 100 parts of the sodium salt of anthraquinonemonosulphonic acid, 250—300 parts of sodium hydroxide, 12—14 parts potassium chlorate, and an amount of H_2O necessary to liquefy the whole mixture. The digester, which is provided with a stirring arrangement so that the mass is kept constantly stirred, is then closed and heated to 180°C . for two days. The fused mass is then dissolved in H_2O and supersaturated with a mineral acid whereby alizarin is precipitated as a yellow precipitate which is then mixed with H_2O to a paste containing 20—50 % of the dyestuff and in this form it is brought into the market.

Of late years alizarin has also been obtained electrochemically by the action of the current on a mixture of anthraquinone and fused caustic alkali.

According to the Germ. Pat. 186526 alizarin is obtained from anthraquinone, not by means of the sulpho-acid, but by fusing the anthraquinone and concentrated caustic alkalies with a small amount of nitrates, chlorates, chromates, or in the presence of air. The method is as follows:— 20—30 kgs NaClO_3

are dissolved in 100 litres H_2O , 300 kg of a mixture of KOH and NaOH are added and then while the mass is being stirred 100 kg anthraquinone are added. The whole is then heated in an oil bath up to 200° until the oxidizing agent disappears, then poured into H_2O . A current of air is then passed through the solution to convert any oxyanthranol, which may have been formed, into anthraquinone, and then the alizarin is precipitated by means of milk of lime. The whole is then filtered and the precipitate decomposed with HCl and after separating the residue the alizarin is freed from anthraquinone by means of dilute lye. Na_2O_2 , BaO_2 , MnO_2 , PbO_2 , HgO etc. may be used instead of $NaClO_3$. The alizarin thus obtained is purer than that formed in the ordinary way and gives particularly beautiful bluish-red shades.

For further information concerning alizarin see article on OXYKETONE-DYES.

Alkalimetry. For convenience' sake by general accord so called NORMAL solutions are used in volumetric-analysis, more especially in alkalimetry and acidimetry. Normal solutions are those which contain in 1 liter of liquid, 1 equivalent of the substance in grms, that is, that amount of substance which is equivalent to 1 atom hydrogen (expressed in grms). More seldom, 1 mol H is taken as the standard, in which case the following figures are to be doubled.

I. HYDROCHLORIC ACID (MURIATIC ACID). HCl. M. Wt. = 36.5.

To prepare the normal solution, pure HCl must be diluted until sp. gr. is about 1.020 and then a small amount of freshly heated chem. pure soda is titrated with it. The exact strength of the acid can in this way be determined, and it is easy to dilute it to the right strength. Another titration is then made as a control. For the preparation of this and all other normal solutions distilled water must be used at a temperature of 15° .

II. OXALIC ACID $C_2H_2O_4 + 2 H_2O$. M. Wt. 126.

To make a $1/10$ -normal solution, 6.3 grms Oxalic acid are dissolved in distilled H_2O and then filled exactly up to the mark of the 1 litre measuring flask.

III. SULPHURIC ACID H_2SO_4 . M. Wt. = 98.

To prepare the solutions, the sp. gr. of the conc. acid is first determined by means of an hydrometer, and from this the strength of the acid can be found. It is then diluted with the exact amount of water, but so that the mixture remains a little stronger than the required normal solution. It is then titrated with a normal alkaline solution (which has been controlled by an oxalic acid solution) and the acid diluted further with water, according to the results of this titration, until the required strength is obtained.

IV. AMMONIA. NH_3 . M. Wt. 17.

The strength of the ammonia on hand is determined either by titration or by finding the S. G. It is diluted accordingly and controlled by another titration.

V. CAUSTIC POTASH. (POTASSIUM HYDROXIDE). KOH. Mol. Wt. = 56.

To prepare a $1/10$ n. caustic potash solution, about 8 grms caustic alkali are dissolved in 250 cc H_2O , heated almost to boiling point, and then baryta water is added by drops until no further precipitate is formed; the excess of baryta is then removed by a solution of potassium carbonate, until no further reaction takes place on the addition of baryta or of carbonate. The liquid is then quickly filtered and diluted with water up to 1 liter. The strength is determined by means of a normal acid and the necessary water added.

VI. POTASSIUM TETRAOXALATE. $KHC_2O_4 + H_2C_2O_4 + 2 H_2O$. Mol. Wt. = 238.

This salt has been much recommended of late years as a volumetric reagent and is obtained by mixing a hot saturated solution of potassium oxalate with

the exact amount of a hot saturated oxalic acid solution. The salt is purified by recrystallizing two or three times from boiling water, and if the hot solution is quickly cooled and stirred, the preparation is obtained in the form of small crystals which have a constant composition.

The following indicators are used.

1. LITMUS (red with acids, blue with alkali).
2. COCHINEAL (yellowish red in acid, violet in alkali).
3. ROSOLIC ACID (yellow in acid, red in alkali).
4. PHENOLPHTHALEIN (colourless in acids (even in CO_2), reddish violet in alkali; NH_3 must not be present).
5. PHENACETOLIN (bright yellow in caustic alkali; dark red in alkali carbonate; golden yellow on addition of acids).
6. METHYLORANGE (red in mineral acids, yellow in alkali; not affected by CO_2 cannot be used for titrating hot solution).

The preparation of the indicators is described under the article INDICATORS; the determination of caustic alkalies, carbonates and bicarbonates is the object of alkalimetry.

FIXED ALKALIES are titrated directly with normal acids. If carbonates are present an excess of acid is added and the CO_2 expelled by boiling; the excess of acid is then back-titrated with normal alkali.

The same method is adopted when the carbonates have to be determined as well as the caustic alkalies. A second portion is in this case treated with barium chloride whereby the carbonates are precipitated, and the alkali is then determined by titration in the filtered or decanted solution. The difference between the total amount of alkali and the caustic alkali corresponds to the amount of carbonate present. If Phenacetoline is employed as an indicator only one titration is necessary: The primary pale yellow colour changes into pink when all the caustic alkali has been neutralized, and then changes again into golden yellow when the carbonates have been neutralized.

If the carbonates and bicarbonates of the alkalies are present at the same time, the total amount of alkali is first determined in one portion and in another portion the carbonic acid due to the bicarbonate.

With this object the second portion is treated with a known amount (an excess) of normal ammonia, whereby the bicarbonate is turned into monocarbonate and at the same time a corresponding amount of ammonium carbonate is formed. The whole of the CO_2 is now precipitated with barium chloride and the excess of NH_3 in the filtrate is determined by means of normal acid. This amount is subtracted from the amount of NH_3 added, and the amount which remains corresponds to the bicarbonate present.

Acids are titrated in the same manner as the simple caustic alkalies.

Alkalimetry and acidimetry are only branches of volumetric analysis; for information concerning the necessary apparatus see article on VOLUMETRIC ANALYSIS. All factories for the preparation of chemicals for analysis manufacture normal solutions of all kinds and concentrations.

Alkali process, electrolytical. See CHLORINE-ALKALI PROCESS, ELECTROLYTICAL.

Alkaloids. Nitrogenous vegetable matters of basic character which form salts with acids. There are volatile and non-volatile alkaloids; most of them contain O, only a few contain no oxygen; most of them are very powerful drugs: many are ranked amongst the most deadly of poisons.

The method of preparation differs, according as the alkaloid is volatile or non volatile.

VOLATILE ALKALOIDS. The finely-cut plants are steeped in H_2O , strong alkalies (NaOH , $\text{Ca}(\text{OH})_2$, or Na_2CO_3) are added and the whole is then distilled with steam. The distillate is neutralized with HCl , evaporated to dryness and the alkaloid salt extracted from the residue with ether-alcohol.

After the evaporation of the solvent the salt is dissolved in H_2O , decomposed with KOH , and the free alkaloid extracted with a suitable solvent (generally ether). The alkaloid obtained after the evaporation of the solvent can be further purified by fractionation *in vacuo*.

Non-volatile Alkaloids. The finely divided plants are boiled with acidulated water filtered, the filtrate treated with excess of alkali ($NaOH$, KOH , Na_2CO_3 , NH_3 , etc) and then extracted repeatedly with suitable solvents, such as ether, petroleum ether, amyl alcohol, chloroform, benzene etc. The impure alkaloid bases are then obtained from these extractions after the solvent has been evaporated. The alkaloids are purified by dissolving them in very dilute acids, filtering through animal charcoal to decolorize the solution, adding KOH to the filtrate and then extracting with some solvent.

The most important alkaloids are treated separately in the present volume, for instance. ACONITINE, ATROPINE, BRUCINE, CAFFEINE, COCAINE, COLCHICINE, COCAINE, CURARINE, DELPHININE, DIGITALINE, EMETINE, HYOSCYAMINE, PHYSOSTIGMINE, PIPERINE, QUININE and the CINCHONA ALKALOIDS (CINCHONINE &c), SOLANINE, STRYCHNINE, THEOBROMINE, VERATRINE. Under OPIUM and OPIUMALKALOIDS will be found CODEINE, MORPHINE, NARCOTINE, NARCEINE, PAPAVERINE and THEBAINE.

SEPARATION OF THE ALKALOIDS.

A. Ether extracts from neutral or acid aqueous solutions

DIGITALINE, COLCHICINE, PICROTOXIN.

Of these Tannin

a) precipitates DIGITALINE, COLCHICINE

b) does not precipitate PICROTOXIN.

B. Ether extracts from alkaline solutions.

1. liquid: CONIINE, NICOTINE.

2. solid: the following alkaloids which give the reactions

a) with cold conc. H_2SO_4 BRUCINE, DELPHININE.

b) with hot conc. H_2SO_4 NARCOTINE, VERATRINE.

c) with conc. H_2SO_4 and pot. bichromate ATROPINE, STRYCHNINE.

d) with conc. phosphoric acid. ACONITINE, DELPHININE.

e) further, alkaloids without one of the preceding reactions. QUININE, HYOSCYAMINE, CODEINE, PHYSOSTIGMINE.

C. Chloroform extracts from alkaline solutions, CINCHONINE, EMETINE, CAFFEINE, CURARINE, MORPHINE, SOLANINE, THEOBROMINE.

With regard to the so-called alkaloid reagents which produce precipitates in all solutions of alkaloids see article on REAGENTS.

ALKALOIDS.

Reactions of the chief Alkaloids.

From Hager's Practical Pharmacy.

(For ERDMANN's and FRÖHDE's reagents see REAGENTS.)

Alkaloid	Pure conc. sulphuric acid	Erdmann's Alkaloid reagent	Fröhde's Alkaloid reagent	Nitric Acid 1.35 to 1.4 S. G.
Aconitine.	Yellow-brown. After 24 hours, reddish-brown with a tinge of violet. After 48 hours, colourless.	Clear yellow- brown Reddish-brown on warming.	Yellow-brown turning colourless.	Yellowish.

Alkaloid	Pure conc. sulphuric acid	Erdmann's Alkaloid reagent	Fröhde's Alkaloid reagent	Nitric Acid 1.35 to 1.4 S. G.
Atropine.	Colourless. Some times brownish	Colourless.	Colourless.	Alkaloid brown dissolving to colourless solution
Berberine.	Dirty olive-green.	Olive-green.	Brownish-green becoming brown.	Dark brownish-red.
Brucine.	Pale rose-red.	Red, then yellow.	Red, turning yellow. Colourless after 24 hours.	Scarlet- to blood-red, then orange.
Caffeine.	Colourless.	Colourless.	Colourless.	Colourless.
Cinchonine.	Colourless.	Colourless.	Colourless.	Colourless.
Cocaine.	Colourless.	Colourless.	Colourless.	Colourless.
Codeine.	Colourless. Blue after 8 days.	Colourless. But soon turning blue.	Dirty-green, soon turning blue. After 24 hours, pale yellow.	Reddish-yellow, then yellow.
Colechicine	Deep yellow.	Yellow.	Yellow, then yellowish-green, finally yellow.	Violet, later brownish-green, finally yellow.
Conine.	Colourless.	Colourless.	Straw-yellow.	Colourless or yellowish, becoming yellow, finally colourless.
Delphinine	Brownish or light-brown. On addition of a few drops of bromine-water, a reddish-violet-colour.	Brownish.	Reddish-brown. Later dirty-brown.	Yellowish.
Digitaline.	Brown, reddish-brown, turning to cherry-red.	Reddish-brown, later red. After 10—15 hours, cherry-red.	Dark orange, soon changing to cherry-red. After 30 minutes, a brownish black. After 24 hours, greenish yellow with black particles.	Pale brown.
Emetine.	Brownish.	Greenish-brown, green, finally reddish-yellow.	—	Orange-yellow.
Morphine.	Colourless. On gently warming, red, then violet, finally dirty green.	Reddish, later brownish-green. On addition of MnO_2 to the freshly-prepared mixture, it turns gradually brown.	Violet, green, brownish-green, yellow, and after 24 hours, bluish-violet.	Dissolves with a reddish-yellow, colour turning yellowish.
Narceine.	Brown, then yellow.	Yellow, then brownish-yellow.	Yellow-brown, yellowish, finally colourless.	Yellow.

Alkaloid	Pure cone sulphuric acid	Erdmann's Alkaloid reagent	Fröhde's Alkaloid reagent	Nitric Acid 1.35 to 1.4 S.G.
Narcotine.	Pale yellow, reddish-yellow; after 30 hours raspberry-red.	Yellowish, then reddish-yellow. On addition of MnO_2 to the freshly prepared mixture, yellowish-red to blood-red.	Green, then brownish-green, yellow, finally reddish.	First yellow, turning colourless
Nicotine.	Colourless.	Colourless.	Yellowish, then reddish.	Yellow with excess of Nicotine, violet to blood-red, finally colourless.
Papaverine.	Violet, then blue.	Violet, then blue.	Violet, blue, yellowish, finally colourless.	Orange-yellow.
Physostigmine.	Yellow then olive-green.	—	—	—
Piperine.	Blood-red, then yellowish-red.	Pale yellow, then brown.	Yellow, turning brown to brownish-black. After 24 hours brownish with black particles.	Orange-yellow resin, turned blood-red by potash.
Quinine.	Colourless.	Almost colourless.	Colourless or greenish solution, turning green.	Colourless.
Solanine.	Reddish-yellow, turning brown after 20 hours.	Pale yellow.	Cherry-red, brownish-red, brown, yellow, finally yellowish-grey.	At first colourless solution, later bluish tinge at edge.
Strychnine.	Colourless. Violet on addition of a small crystal of $K_2Cr_2O_7$.	Colourless. With addition of MnO_2 violet-red, then dark red.	Colourless.	Yellow.
Thebaine.	Blood red, later yellowish-red.	Blood-red, later yellowish-red.	Red, then reddish-yellow, finally colourless.	Yellow.
Theobromine.	Colourless.	Colourless.	Colourless.	Colourless.
Veratrine.	Orange, blood-red. After 30 minutes carmine red. When the fresh solution is treated with bromine water, purple.	Orange, red to carmine. On addition of a few drops of water, cherry-red.	Very yellow, later cherry-red.	Yellowish.

Alkanna. A dark-red dyestuff, obtained from the roots of *Anchusa* (*Alkanna*) *tinctoria*. It forms a friable mass with a metallic reflex, softening at 100° with no definite melting point. Insoluble in water, soluble in alcohol, ether, chloroform fats, oils &c. It turns blue in presence of alkalies. Used for colouring oils, pomades &c.

Blicher.

Alkermes see **KERMES**.

Alloys. See especially „ALUMINIUM ALLOYS“, „ANTIMONY ALLOYS“, Iron alloys etc., further „BRONZES“. Easily melting alloys see under „CADMIUM ALLOYS“ and „BISMUTH ALLOYS“, also „SOLDERING“.

Almatein. A condensation product of haematoxylin and formaldehyde. Prepared according to Germ. Pat. 155630 by the action of formaldehyde on logwood extract.

It forms a red powder without taste or odour, almost insoluble in water, sparingly soluble in ether, CHCl_3 and CS_2 , moderately soluble in alcohol and acetic acid and readily in glycerine. Used medicinally.

Almond oil. A fatty oil obtained from the sweet or bitter almonds of *Amygdalus communis*, by grinding the almonds and pressing cold. Usually a mixture of the two kinds is used. The oil becomes clear on standing and is then obtained as a yellowish, mobile, odourless liquid with a sweet and not unpleasant taste. S. G. (at 15°) 0.919. It solidifies at -21° ; is a non-drying oil but becomes rancid in the air. It is decolourized by light. Iodine number 82—99 Saponification number 195.5. It is used in medicine and in the manufacture of cosmetics. The residue left after pressing is also used for toilet purposes (almond meal). See also BITTER ALMONDS, OIL OF.

Alpaca see **NICKEL ALLOYS**.

Alphaeucaine see **EUCAINE**.

Alphozone. Disuccinylperoxide $(\text{COOH} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO})_2 \cdot \text{O}_2$. A new antiseptic with remarkable germ-killing power. The solution 1 : 5000 kills typhoid bacilli in a minute.

Alsol (Aluminium aceto-tartrate) obtained by evaporating on the water bath 100 parts of freshly prepared aluminium acetate solution with 3.5 parts of tartaric acid. It forms a colourless acidic mass readily soluble in H_2O insoluble in alcohol. It is used in medicine externally for the treatment of wounds, for a mouth wash and for gargles, &c. According to the latest experiments, its antiseptic power does not seem to be very remarkable.

Alumen = Potassium alum see **ALUMS**.

Alumen ammoniacale = Ammonium alum see **ALUMS**.

Alumen chromicum = Chrome alum see **ALUMS**.

Alumen concentratum = aluminium sulphate see **ALUMINIUM COMPOUNDS**.

Alumen cubicum = cubic alum see **POTASSIUM ALUM** in article **ALUMS**

Alumen natrium = sodium alum see **ALUMS**.

Alumen romanum = Roman alum see Potassium alum under **ALUMS**.

Alumen ustum = burnt alum see in Potassium alum under **ALUMS**.

Alumina = aluminium oxide see **ALUMINIUM COMPOUNDS** No 8.

Aluminium. Al. A. W. 27.1 is a silver white metal of sp. Gr. 2.64 to 2.70 M. P. 700° Readily soluble in caustic alkalies and in aqueous hydrochloric acid.

Aluminium is obtained either by purely metallurgical methods or by electro-metallurgical means. The oldest metallurgical process (DEVILLE) consists in reducing the halogen compounds of Al by means of Na. For this purpose bauxite $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ is taken and fused with soda, thus forming sodium aluminate. Alumina Al_2O_3 can be obtained from the latter, and this by heating with charcoal in the presence of chlorine is converted into aluminium chloride. On heating the latter with metallic sodium, aluminium is obtained. Most of the improvements have been devised with the object of making the process

cheaper and of simplifying the method of production of aluminium chloride and sodium. Very often the natural cryolite ($\text{AlF}_3 + 3\text{NaF}$) is used as a starting point. This can be reduced to the metal just as easily as the chloride. In GRABANS process artificial cryolite is made from aluminium sulphate, and this is then submitted to reduction. According to the Germ. Patents 140231 and 141005, very pure alumina is heated to about 1800° , ground, mixed to a paste with calcium phosphate, sulphuric acid, petroleum, and an excess of lime, and then heated in a crucible to $1200\text{--}1600^\circ$ in absence of oxygen. (This object may be attained by packing the mass in coal-dust.) The aluminium, which is found under the slag, is as pure as that obtained by electrolytical methods, and is very much cheaper.

According to the Germ. Pat. 160286 aluminium compds. (e. g. $\text{Al}_2(\text{SO}_4)_3$) may be reduced at sufficiently high temperatures by the action of sulphurous acid, the compressed stream of gas being allowed to pass upwards.

The ELECTROLYTICAL method of obtaining aluminium consists in melting oxygen compounds, in the presence of reducing agents, in the electric furnace i. e. by means of the electric arc. At first the production of aluminium alloys was aimed at, and on this account iron, tin and especially copper, were added to the mass. In the new Héroult process alumina is decomposed without any flux between a positive electrode consisting of a bundle of copper rods, and the negative of some molten metal, e. g. copper, which latter combines with the aluminium forming aluminium bronze. Pure aluminium may be obtained directly by electrolyzing the double fluorides of alkali and aluminium in vessels lined with fireclay, whereby the electric arc, produced between two infusible electrodes, melts the powdered contents and liberates the aluminium.

The positive electrode now usually consists of a bundle of carbon rods and the cathode is formed by molten aluminium on the bottom of the crucible. (which is usually of carbon or of iron lined with carbon.) The operation is continued uninterruptedly, the aluminium produced being let off at the taphole and cast into bars.

According to the Germ. Pat. 133508, Al is obtained from Al_2O_3 by desiccating the latter through roasting, mixing it with tar, and gradually bringing the mixture into a vessel heated to $1300\text{--}4500^\circ\text{C}$. At the same time hot chlorine is also passed in. (The chlorine is obtained by electrolysing melted NaCl at a temp. of 1000° with a potential of 4.5 volts.) Aluminium chloride Al_2Cl_6 and CO are formed and these pass in the form of vapour into a second receiver which is not heated and into which the sodium obtained from the above mentioned electrolysis passes in the form of vapour. In this way the sodium combines with the chlorine, and aluminium is formed, while the sodium chloride passes back to the electrolysing apparatus to be decomposed again into Na and Cl. The process is thus continuous and to a certain extent automatic and very little energy is required. The American Aluminium industry is constantly endeavouring to make itself independent of the German production of aluminium oxide. The Germ. Pat. 143091, according to which bauxite is melted with charcoal in the electric furnace, has the same object. By this means a fairly pure aluminium oxide is obtained, which is treated in the ordinary way for Al.

The Germ. Pat. 133909 (mentioned below) has the same object and aims at refining the aluminium obtained from the impure Al_2O_3 (Bauxite).

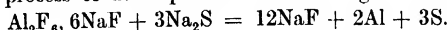
A French process (French Pat. 334132) consists in the reduction of Al_2Cl_6 by means of zinc sodium ZnNa_2 . This reducing alloy is obtained by electrolysis and is used directly for the treatment of bauxite whereby the electrolyte is continuously formed.

According to the Germ. Pat. 148627 (compare Chem.-Ztg. 1904, 157) Al may be obtained, and the electrolytes and auxiliary materials recovered,

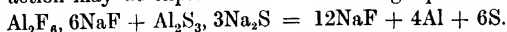
by subjecting a melted mixture of sodiumfluoraluminate and sodium sulpho aluminate (Al_2F_6 , $6\text{NaF} + \text{Al}_2\text{S}_3$, $3\text{Na}_2\text{S}$) to electrolysis. This mixture is obtained by the action of 2 mol. of aluminium fluoride on 6 mol. of sodium sulphide. The sulpho aluminate, the heat of formation of which is considerably less than that of the fluoraluminate, is alone decomposed by the current, according to the equation, Al_2S_3 , $3\text{Na}_2\text{S} = \text{Na}_2 + 2\text{Al} + 3\text{S}$.

The sodium sulphide thus formed reacts with the fluoraluminate, and sulpho-aluminate is again formed, which is in its turn also decomposed by the current, and so on, until all the Al and the sulphur have been separated and the sodium is turned into fluoride.

The second process of decomposition is according to the equation,



The whole action may be expressed in the following equation:



In order to melt the electrolytes and to keep the bath at a temp. of about 850° during the electrolysis an E. M. F. of 5–6 volts and a current-density 0.6 amp per 1 sq cm is necessary. Bauxite serves as the raw material, from which aluminium fluoride is made in the following way. The raw bauxite is first of all dried, then finely powdered, and treated in a mixer with hydro-fluoric acid at the ordinary temperature so that aluminium fluoride, iron fluoride aluminium fluosilicate and aluminium fluotitanate are formed. If aluminium oxide is added to this solution then iron, silica and titanitic acid are precipitated. The decanted solution is concentrated by evaporation, when an insoluble precipitate of aluminium fluoride forms. This is separated from the mother liquor, dried, and then heated in a muffle furnace to remove the last traces of water. The sodium sulphide is obtained by the reduction of anhydrous sodium sulphate and the accessories, sodium sulphate and hydro-fluoric acid are recovered in the course of the process.

Several processes produce a more or less impure Al, and in such cases the electrolytical purification (according to the Germ. Pat. 133909) may be of importance. For this purpose, a cell is used in which the electrolyte consists of a mixture of fused aluminium fluoride and the fluoride of a metal more electropositive than Al. The anode is the impure Al in a molten state. As soon as the current is passed through, pure Al is deposited on the cathode.

According to Germ. Pat. 186182, the electrolytic refining of Al is carried out by using an aluminium-containing electrolyte of greater density than pure aluminium and of a lower density than the material of which the anodes are composed. The object of this is to make the effect greater by having the cathode surfaces brought together more closely without the danger of establishing a short circuit. An alloy of Al and the heavy metals is used as anode. This generally consists of a product resulting from the reduction of a mixture of aluminium ores and the heavy metals or their oxides.

The Germ. Pat. 131517 and 137003 treat of processes for increasing the tensile strength, density, and firmness of Al. The process consists in the addition of from 2–15 % P; with 2 % P, the alloy is easily malleable; with 3 %, it is specially adapted for horse-shoes; with 4–7 %, it is an excellent substitute for bronze with small contraction which can be readily soldered, and is only oxidized with difficulty. With 7–15 %, it is extremely hard and tough, so that it is best used in the form of wrought blocks.

The future predicted for aluminium, having regard to the many purposes for which it seemed suitable, has only been partially realized. It is used in the iron and steel industry, for the manufacture of soldiers' canteens and bottles, small boats, instruments and weights &c. Of late years it has been largely used as a material for telephone wires. Nowadays the amount of Al used has been greatly increased by its being recognised as a very useful material for

various pieces of apparatus used in chemical industries; in the manufacture of stearine, for example, utensils of Al are much to be preferred to those of Cu and Cu alloys since Al is only very slightly attacked by the fats and fatty acids even when heated in the presence of air. Such utensils are now usually prepared by a new process of welding invented by HERAEUS (Germ. Pat. 118868). Excellent results are obtained by the autogenous welding of aluminium according to the method patented by SCHOOP (cf Chem.-Ztg. 1907, 749). According to this patent, the welding is conducted in presence of an aqueous solution of a chloride of the alkali metals. This secures the absence of air and also the reduction and absorption of any oxide that may be formed.

The soldering of Al however still presents many difficulties. One of the best solders consists of 1 Al 1 P 11 Zn 29 Sn. No acid is required in soldering.

The English Pat. 4973 of 1904 protects an aluminium solder of 100 parts Zn 2 pts Bi and 1 pt Ni; the metals are melted in a graphite crucible. The articles to be soldered are heated to 100°C, rubbed with stearic acid and then soldered. — It is difficult to find much worth patenting in this process.

Other aluminium solders are protected by the Eng. Pat. 13328 (1904) and 17031 (1905) and also by the French. Pat. 373824.

The English Pat. 21609 (of 1903) deals with the electrolytical deposition of metals on Al: The Al objects are first treated with a solution of stannous chloride and ammonium alum and in this way covered with a thin layer of tin. This can then be coated electrolytically with any other metals.

The Germ. Pat. 163545 and 182421 describe a method for the oxidation and colouring or enamelling of aluminium articles. This consist in first heating them with a solution of a mercury salt and then removing the layer of amalgam so formed. In this way the surface becomes coated with a layer of Al_2O_3 which on heating forms a suitable ground for enameling. The surface may be treated with a solution of chromic acid. Subsequent heating fixes the colour as a thin layer capable of resisting heat. A similar result can be obtained with the chlorides of certain other metals without the preliminary treatment with mercury salts.

Different alloys of Al have proved themselves much more valuable than Al itself. (Compare article ALUMINIUM alloys.) Al has found a new use within recent times which may prove of great practical importance. See article on THERMITE.

Aluminium:

The British Aluminium Co. Ltd., 109 Queen Victoria St., London E.C.

Aluminium alloys. As already stated the alloys of Al may lay claim to special importance on account of their many excellent qualities.

1. **ALUMINIUM BRONZES.** Alloys of Cu and Al with a preponderating amount of Cu have very different qualities according to the proportions of the components. They are either prepared as described above directly by the electrolysis of Al compounds in the presence of Cu, or by adding pure Al to melted copper. Very pure Al bronzes are obtained by the latter method while the product of the electric furnace nearly always contains silicon and iron.

The aluminium bronzes mostly contain 3—10 % Al, sp Gr 8.37—7.65; colour reddish gold to bright yellow. The common aluminium bronze with 10 % Al melts at about 1100°C. The electrical conductivity of bronzes with 5—10 % Al amounts to 13—6 % of that of Cu. Aluminium bronze offers great resistance to the action of oxidizing agents, mineral acids, common salt, ammonia, sulphur, alkalies, alum, chlorine, sulphite lyes &c.

The Germ. Pat. 144340 protects the manufacture of manganaluminium bronze in which the amount of Al is half that of the manganese (10% or less). For example one alloy consists of 9—10 % Mn, 90—91 % Cu and 4½—5 % Al.

2. **ALUMINIUM BRASS.** Usually a brass containing about 33 % Zn is used to which 0.5—4 % Al is added. These alloys can be welded at a dark red heat and have many other valuable properties. They are generally used instead of the dearer Al bronzes when no especial resistance to the action of reagents is required.

3. **ALUMINIUM ZINC.** Besides **MAGNALIUM** (see No 10), **ZINALIUM** (see No 12), and **ZINKALIUM** (see No 13) alloys of Al and Zn have been introduced especially one containing 3 parts Al and 1 pt Zn which can be worked with ease.

4. **ZISCON.** Another aluminium zinc alloy, containing 3—4 pts Al for 1 pt Zn. Sp. Gr. = 3.35.

5. **ALZEN.** An alloy containing 2 parts Al and 1 part Zn.

6. **CISUM.** An alloy in which Al Zn Sn and Cu as well as traces of Sb and Bi are found. Sp. Gr. 2.95.

7. **ALUMINIUM CADMIUM.** The English Pat. 16453 (of 1903) protects alloys which are specially adapted for castings and can be easily worked. The alloys consist either of 93.5 pts Al 2.5 parts Cd and 4 pts. Cu or of 90.5 pts. Al 3.5 pts. Cd and 6 pts. Cu.

8. **ALUMINIUM NICKEL.** (See **NICKEL ALLOYS** no. 5). According to the Germ. Pat. 133910 an alloy of Al with Ni Fe and Bi has very valuable properties, especially when it has the following composition 900 pts. Al, 50 pts. Bi, 25 pts. Fe, and 25 pts. Ni. In manufacturing it the iron is first melted and then the other metals added one by one. This alloy is said to possess besides the lightness characteristic of Al the property of being easily fusible and of being easy to solder; it is also not readily attacked by oxidising agents.

9. **ALUMINIUM NICKEL TITANIUM.** The Germ. Pat. 154485 protects those alloys which unlike aluminium nickel do not form flaws when cast. In order that the alloy may possess this property, not more than 2 % Ti and 3.5 % Ni must be present. An alloy of 97.6 % Al, 2 % Ni and 0.4 % Ti possesses great tenacity and forms good castings.

- 10. **MAGNALIUM;** an alloy of aluminium and magnesium. It seems most remarkable that alloys of Al, and Mg, the first of which has many defects and the second offers so little resistance to the action of damp air that its use for metallurgical purposes would appear to be impossible, should show such remarkable properties.

Magnalium has entirely different properties according to the proportions in which the components, are combined. Those alloys with 10—30% Mg are malleable, have a S. G. 2—2.5, are suitable for casting and are easily worked without softening. All these alloys are capable of a high polish and do not readily fracture.

Those alloys which contain a large percentage of Mg and only a small amount of Al are not so good as the preceding. The hardness, brittleness, and power of taking a high polish increase with increasing amounts of magnesium; alloys with more than 30% Mg are hard to work in the lathe. Magnalium is manufactured by electrolysing magnesium compounds (carnallite or tachydrate) just below a red heat and adding Al during the electrolysis.

The valuable properties of those alloys known under the name magnalium assure them a wide application for such objects as highly polished, silver-white, but very light optical mirrors, for graduated instruments, for mountings of lenses, for axles, clock wheels, fuses for projectiles, for parts of machines in electrical work and in the automobile industry etc. It may also be remarked that the common magnalium (10 % Mg) can be soldered and may also be nickelplated and goldplated; its silver-white colour may also be turned black by "pickling". S. G. 2.4—2.57. M. P. 650°—700°. Its tensile strength per sq. mm. = 24 kg (while that of Al is only 7 kg; of brass, 17 kg, and of bronze 20 kg).

11. **ALLOYS x, y, z.** These aluminium alloys are much used; like magnalium they contain Mg. According to BARNETT's analyses the alloy x contains

1.76 % Cu, 1.60 % Mg, 1.16 % Ni and small amounts of Sb and Fe. Alloy y contains Cu, Mg, Sn, Pb, and small amounts of Fe, alloy z: 3.15 % Sn, 0.21 % Cu, 1.58 % Mg, 0.72 % Pb and 0.3—1 % Fe. Traces of Ti are found in all these alloys. It is noteworthy that none of these alloys contains more than 2 % Mg.

12. ZIMALIUM. An alloy prepared (according to the Germ. Pat. 141190) from 100 parts Al, 1—10 parts Mg and 1—20 parts Zn. The alloy is harder and better to work than Al; sp. Gr. 2.65—2.75. Wire and sheets made of this alloy resemble brass. The tensile strength is twice as great as that of Al. Castings can be filed, welded, shaped, and planed, and have a tensile strength of 14—20 kgs by quickly cooling, of 20—25 kg (as compared with 3—8 and 10—12 kg respectively Al). The alloy is 10—12 % dearer than Al. Zimalium offers less resistance to the action of chemical agents than Al and the electric conductivity is only $\frac{2}{3}$ of that of the pure metal.

13. CALCIUM ALUMINIUM. The process (Germ. Pat. 144777) for manufacturing calcium aluminium alloys with a high percentage of Ca is rather interesting. Molten Al is used as the cathode by the electrolysis of fused CaCl_2 . Alloys containing up to 97 % Ca may be prepared in this way; their properties resemble in a marked fashion those of pure calcium (see CALCIUM).

The other aluminium alloys such as aluminium iron, aluminium steel, aluminium silver, aluminium German silver etc. are of less importance. The Germ. Pat. 152784 protects the manufacture of alloys of Al, Sn, Sb, Cu, and Mg; the English Pat. 14936 of 1902 that of alloys of Al and Fe.

Aluminium iron and aluminium steel are mentioned under IRON ALLOYS. Compare also art. on ZINKALIUM.

Aluminium alloys:

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Aluminium compounds. These are described in alphabetical order but only those are considered which are of technical importance.

1. ALUMS see the special article.

2. ALUMINIUM ACETATE. $\text{Al}_2(\text{C}_2\text{H}_3\text{O}_2)_6$. Obtained either by decomposing $\text{Al}_2(\text{SO}_4)_3$ with $3\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ or with $3\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ or by dissolving precipitated $\text{Al}_2(\text{OH})_6$ in $\text{C}_2\text{H}_4\text{O}_2$. The solution is quickly changed into basic acetate. If the solution be evaporated below 40° $\text{Al}_2(\text{C}_2\text{H}_3\text{O}_2)_4 \cdot (\text{OH})_2 + 3\text{H}_2\text{O}$ remains. According to the Germ. Pat. 160348 a valuable insoluble basic aluminium acetate containing 72 % acetic acid is obtained by heating an aqueous solution of the neutral acetate under pressure, or with acetic acid. The formation of the precipitate is favoured by starting with a concentrated solution. Aluminium acetate is used to some extent in surgery, but principally as a mordant in dyeing (see ALUMINIUM MORDANTS).

3. ALUMINIUM CHLORIDE Al_2Cl_6 . Prepared by heating aluminium oxide with coke in a current of chlorine. A perfectly pure product is also obtained by heating metallic Al in a current of chlorine. According to FAURE a mixture of Al_2O_3 and coal is heated to a red heat by means of hot producer-gas. When the air, moisture, and CO_2 , have been expelled the producer-gas is turned off and HCl vapour is allowed to act under reduced pressure. — An aqueous solution of aluminium chloride is obtained by dissolving $\text{Al}_2(\text{OH})_6$ in HCl; this solution is used as a disinfectant. Al_2Cl_6 is also used (instead of H_2SO_4) for carbonising wool, since it decomposes at 125° into Al_2O_3 , H_2O (steam), and HCl. The latter causes the carbonisation.

Al_2Cl_6 is a colourless leafy crystalline mass, very deliquescent and fuming in the air, soluble in H_2O , alcohol and ether.

4. ALUMINIUM FLUORIDE AlF_3 . Obtained by treating Al_2O_3 or $\text{Al}_2(\text{OH})_6$ with HF; it is a substance insoluble in H_2O and not attacked by acids and aqueous alkalis. The double salt, aluminium sodium fluoride $\text{AlF}_3 \cdot 3\text{NaF}$,

is important, and is known as CRYOLITE. It is obtained artificially in the form of a white, transparent mass, insoluble in H_2O , by evaporating a mixture of 1 mol. Al_2O_3 , 3 mol. Na_2CO_3 with HF and heating the residue.

5. ALUMINIUM SODIUM CHLORIDE $Al_2Cl_6 + 2 NaCl$.

Obtained by heating aluminium oxide with coal and common salt in a current of chlorine. Colourless crystalline mass M. P. 185° ; is used in the preparation of aluminium.

6. ALUMINIUM NITRATE $Al_2(NO_3)_6$. Obtained by dissolving Al_2O_3 in HNO_3 . It forms a deliquescent crystalline mass containing 15 molecules of water of crystallization. M. P. 70° . It is used as a mordant in dyeing.

7. ALUMINIUM OXALATE. It exists both as a neutral salt $Al_2(C_2O_4)_3$ and as acid salt, and is obtained by dissolving $Al_2(OH)_6$ in $C_2H_2O_4$. Crystalline powder used as a mordant in calico printing.

8. ALUMINIUM OXIDE (ALUMINA) Al_2O_3 . Obtained by heating $Al_2(OH)_6$, ammonia alum and other aluminium compounds containing volatile acids.

The methods for manufacturing it from bauxite — a naturally-occurring, impure aluminium oxide, — are of special importance. There are three principal methods, which are as follows:—

I. The fusion of bauxite with Na_2CO_3 in a reverberatory or muffle-furnace; from the $NaAlO_2$ so formed Al_2O_3 is precipitated by means of CO_2 , and the Na_2CO_3 produced used again.

II. The dry method of PENIAKOFF (Germ. Pat. 80063 and 93952) by which bauxite is fused with Na_2SO_4 and C, or with Na_2SO_4 and Na_2S , or with $Na_2SO_4 + FeS_2$ (Pyrites). SO_2 is obtained here as a by-product.

III. The wet method of BAYER (Germ. Pat. 43977 and 65604) in which bauxite is treated with NaOH in autoclaves and then the Al_2O_3 precipitated from the $NaAlO_2$ thus formed by adding a small amount of Al_2O_3 with stirring. According to the French Pat. 344296 the operation is carried out by heating with a solution KOH or $Ca(OH)_2$ under great pressure. According to the English Pat. 9024 (1903) bauxite is treated with HF or H_2SiF_6 , the Al_2F_6 separated, and then treated with superheated steam. The HF thus liberated is condensed and used again in the process. According to the Germ. Pat. 135553 and 138219 pure aluminium oxide is obtained from bauxite in the electric furnace by mixing it with coal, adding as a flux CaO , Na_2CO_3 , cryolite or fluor-spar, and, when necessary also adding Al or Fe_2O_3 and also as a flux, CaO , Na_2CO_3 , cryolite, Al or Fe_2O_3 . The impurities are said to be converted by this means into an alloy of iron and aluminium or into iron silicide, which can be easily removed.

In this process the bauxite is mixed with caustic lime and treated under a pressure of 10 atmospheres, with Na_2CO_3 solution. The solution of sodium aluminate is then filtered as usual and precipitated with CO_2 . The Amer. Pat. 740364 protects the manufacture of Al_2O_3 from $Al_2(SO_4)_3$ which also contains iron, by mixing it with NaCl, H_2O and coal, and heating the mixture in the presence of steam to a red heat. The mixture is lixiviated with water and the Na_2SO_4 allowed to crystallise. The sodium aluminate and iron sulphide are precipitated from the filtrate, and the Na_2CO_3 recovered from the solution.

According to the Amer. Pat. 826354, bauxite is treated with a solution of a calcium compound. The calcium aluminate so formed is treated with Na_2CO_3 and the sodium aluminate produced separated from the insoluble residue. The Al_2O_3 is precipitated from the solution.

The Germ. Pat. 175416 describes a wet process for obtaining Al_2O_3 from bauxite, in which 1 mol. Al_2O_3 is treated with 1.7 mols. Na_2O (in the form of NaOH) in open vessels. This method obviates the use of increased pressure.

The Germ. Pat. 182775 describes an improvement of the wet methods of preparation.

According to the Germ. Pat. 180554 and 185030 the fused mass obtained in the Peniakoff method is extracted with water, and the solution treated

after heating with SO_2 . The aluminium oxide separates in the hydrated form, while at the same time sodium thiosulphate is produced.

Instead of SO_2 , H_2S may be used when Na_2S is obtained as a by-product.

Perfectly anhydrous Al_2O_3 may be obtained according to Germ. Pat. 165612 by calcining aluminium hydroxide in presence of small quantities of fluorine compounds. Complete calcination can thus be secured at a comparatively low temperature.

The Germ. Pat. 143901 treats of the purification of crude alumina.

Al_2O_3 has a S. G. 3.75—3.99; in the amorphous state it is readily soluble in acids but insoluble in the crystalline state. It dissolves in KHSO_4 and in fused alkalis.

It is used in the manufacture of Al as a source of Al_2Cl_6 ; the aluminium oxide being heated with coal in a current of chlorine.

9. ALUMINIUM HYDROXIDE $\text{Al}_2(\text{OH})_6$. Occurs naturally in different minerals. Obtained artificially by heating cryolite with caustic lime or from bauxite and soda. According to the English Pat. 3776 (1904) for the manufacture of very pure aluminium hydroxide suitable minerals such as leucite are treated with H_2SO_4 . Alum separates in the crystalline form. It is redissolved and ammonium carbonate added to the solution, when $\text{Al}_2(\text{OH})_6$ is precipitated. The sulphates in the mother liquor can be used for other purposes.

$\text{Al}_2(\text{OH})_6$ is insoluble in H_2O , soluble in acids and alkalis. S. G. 2.3. With alkalis it forms salts in which it plays the part of an acid. Of these aluminates, the sodium salt $\text{Al}_2(\text{NaO})_6$ is especially important. The aluminates are used as mordants. (For information about aluminates, see Amer. Pat. 740364 mentioned under Aluminium oxide 8.)

10. ALUMINIUM SULPHOCYANIDE. Is obtained by precipitating a strong solution (44° Baumé) of $\text{Ba}(\text{CNS})_2$ or of $\text{Ca}(\text{CNS})_2$ (36° Baumé) with a solution of $\text{Al}_2(\text{SO}_4)_3$ (30° Baumé). It may be obtained commercially in solution (19°—22° Baumé) and is used as a mordant in cotton printing.

By dissolving $\text{Al}_2(\text{OH})_6$ in aluminium sulphocyanide, different basic sulphocyanides have been obtained.

11. ALUMINIUM SULPHATE $\text{Al}_2(\text{SO}_4)_3$. By treating cryolite, or bauxite, or alumina with H_2SO_4 impure products are obtained. On the other hand a pure product is obtained by dissolving aluminium oxide free from iron (obtained from bauxite or cryolite) in dilute H_2SO_4 . The purification of aluminium oxide (which contains iron) with the object of obtaining $\text{Al}_2(\text{SO}_4)_3$ is the subject of the Amer. Pat. 752927. The raw materials are subjected to chlorinating agents in order to convert the Fe into Fe_2Cl_6 and then the latter salt is removed by volatilization. Care must be taken that the temp. does not become too high, otherwise the Al compounds become insoluble. The residue is treated with H_2SO_4 and hot air blown into the mixture. The sulphate solution is then separated from the insoluble residue and concentrated. According to the Germ. Pat. 131314 in order to obtain very pure $\text{Al}_2(\text{SO}_4)_3$ in a crystalline form, the solution is evaporated *in vacuo* at 50—70°, more solution being added to increase the size of the crystals. The crystalline mass is then separated from the mother liquor by suction or by centrifuging. It crystallizes with 18 mols. of water. The crystals are readily soluble in H_2O sparingly soluble in alcohol, do not decompose in the air and have a S. G. of 2.71. Owing to the reduction in the price of aluminium sulphate it has been used largely in place of the alums. (See article on ALUMS and ALUMINIUM MORDANTS.)

According to the French Pat. 331836 a readily soluble basic aluminium sulphate may be obtained by adding chalk that has been thoroughly washed to a solution of $\text{Al}_2(\text{SO}_4)_3$ in H_2O and evaporating carefully after the removal of the CaSO_4 . After cooling the crystallisation of the basic sulphate $\text{Al}_3(\text{SO}_4)_2$ is induced by the addition of a few crystals of the salt. The same salt may

be obtained (according to the English Pat. 25683, (1902)) by passing NH_3 into a hot solution of $\text{Al}_2(\text{SO}_4)_3$ until ammonium alum crystallizes out on cooling. The mother liquor containing the basic sulphate is carefully evaporated *in vacuo*. The same salt may also be obtained (Germ. Pat. 167419) by allowing an excess of hot H_2SO_4 to act on Al_2O_3 under pressure. The whole is then filtered, the filtrate evaporated *in vacuo*, and the crystals separated from the mother liquor. The Amer. Pat. 781341 aims at manufacturing a double sulphate of sodium and aluminium. Salpetre cakes are dissolved, 1.5–2% alkalisulphide added and the insoluble matter allowed to settle. Then a sufficient amount of $\text{Al}_2(\text{SO}_4)_3$ solution is added to the clear solution obtained above, and also $\frac{1}{2}\%$ free acid; the whole is concentrated and the double sulphate so formed is calcined.

12. SODIUM ALUMINATE see No. 9 ALUMINIUM HYDROXIDE, ALUMINIUM COMPOUNDS.

Aluminium compounds:

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Aluminium mordants.

I. ALUM. POTASSIUM ALUM and AMMONIUM ALUM are often used as mordants for dyeing. By adding CaCO_3 , Na_2CO_3 etc. the alum solutions are converted into basic salts (so called neutralised alums). The alums are all used as mordants for wool. (See ALUMS.)

II. ALUMINIUM SULPHATE. Only those products which are free from iron and acid may be used as mordants. As the basic salts are much easier to decompose than the neutral sulphate the solutions are treated with CaCO_3 , Na_2CO_3 , NaHCO_3 or $\text{Al}_2(\text{OH})_6$, by means of which basic aluminium sulphates of different compositions are formed.

Such basic solutions are used especially as mordants for cotton. After the aluminium hydroxide has been precipitated on the fabric it is dried and rendered insoluble by treating with ammonium sodium phosphate, ammonium carbonate, silicate or soap. On the other hand, the neutral sulphates are used as mordants for wool and silk.

III. ALUMINIUM ACETATE. Preparation see under ALUMINIUM COMPOUNDS. The product obtained by the action of lead acetate on alum is probably aluminium acetate and sulphate with a small amount of K_2SO_4 ; it is an efficient mordant. In order to dispense with the preparation of lead acetate, the basic aluminium sulphate is precipitated from solutions of alum or aluminium sulphate by Na_2CO_3 , and is then dissolved in acetic acid. These solutions have been termed red mordants, because they are used for producing the red madder or alizarin colours in cotton dyeing, and especially in calico printing. Compare article TURKEY-RED DYEING.

IV. ALUMINIUM CHLORIDE. For general information see article on ALUMINIUM COMPOUNDS. It is rarely used as a mordant, but is employed for the carbonisation of wool. (See note on ANIMAL FIBRES.)

V. ALUMINIUM OXALATE. For general information see ALUMINIUM COMPOUNDS. It is used at times in calico printing for producing certain special colours. The same remarks apply to ALUMINIUM TARTRATE.

VI. ALUMINIUM SULPHOCYANIDE. See article on ALUMINIUM COMPOUNDS. It may be used advantageously in cotton printing instead of aluminium acetate mordants, because it does not attack the steel doctors like the acetate.

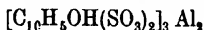
VII. SODIUM ALUMINATE. See article ALUMINIUM COMPOUNDS. The mordant is thickened by the addition of dextrine, and then (in calico printing), brought on to the fabric. The latter is then drawn through a solution of sal ammoniac by which means the aluminium hydroxide is precipitated or fixed on the fibres.

Aluminium mordants:

Willy Manger, Dresden, Germany.

Aluminothermy see **THERMITE**.

Alumol is the aluminium salt of β -naphtholdisulphonic acid



It is obtained by the action of $\text{Al}_2(\text{SO}_4)_3$ on the Ba salt of β -naphtholdisulphonic acid. Very fine powder which is almost white. Soluble in cold H_2O . It has reducing properties.

It is used as an antiseptic and astringent and also as a caustic for wounds, ulcers, skin-diseases etc. and especially for gonorrhoea. Solutions of 0.5–3 % are used as antiseptics, 10–20 % solutions as caustics, and 2–5 % solutions in gynaecology.

Alums. Under this name are included double sulphates of the alkali metals and aluminium; the alkali metals may be replaced by certain other metals and the alumina by certain sesquioxides (e. g. Fe_2O_3 , Cr_2O_3 , Mn_2O_3). The most important alums are the following: —

1. **POTASH ALUM** (Ordinary alum). $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24 \text{H}_2\text{O}$. The whole of the alum used commercially is prepared artificially from *alum stone* (basic potassium aluminium sulphate), from *alum shale* or from *bauxite* and *cryolite*.

Alum stone contains all the constituents of alum, the alum shale contains the aluminium and sulphate portion, while bauxite and cryolite (as also clays poor in Ca and Fe) contain aluminium only. The method of manufacture is based upon these differences.

Alum stone is broken into pieces and burnt at a temperature not exceeding 500° . It is then extracted with warm water and the solution concentrated. The Roman alum thus obtained is valued on account of its purity. It is also known as cubical alum since it crystallizes in cubes and not in octahedra.

The largest amounts of alum are prepared from alum shale which is piled in heaps and allowed to weather — in some cases it is necessary to roast the shale — when aluminium sulphate is formed. The mass is extracted, the solution concentrated and after numerous processes of purification treated with potassium sulphate, thus forming alum. By vigorous stirring the alum can be made to separate in a fine state (alum meal).

Bauxite and cryolite are roasted, powdered and treated with hot sulphuric acid. The product is extracted with water and the solution treated with potassium sulphate.

Potash alum forms large, clear octahedra, soluble in 10.5 parts of cold ($+10^\circ$) and in 0.75 parts of boiling water. When heated to 120° it loses water and falls to a loose powder (burnt alum, *Alumen ustum*).

Alum is used in dyeing as a mordant, for the preparation of colour lakes, in the manufacture of white leather, for sizing paper, to harden plaster of Paris, in medicine, &c., &c.

2. **AMMONIUM ALUM.** $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24 \text{H}_2\text{O}$. It is obtained from alum stone, bauxite, cryolite &c. as in the manufacture of potash alum, the only difference being that ammonium sulphate is substituted for potassium sulphate. In appearance it is exactly similar to potash alum. 100 parts of water dissolve 9 parts at 10° and 422 parts at 100° . It is used principally for the preparation of very pure alumina which is obtained from it by strongly igniting the salt.

3. **SODA ALUM.** $\text{Na}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24 \text{H}_2\text{O}$. It is obtained from sodium and aluminium sulphates. It is less used than either potash or ammonium alum on account of its greater solubility. This property renders purification by recrystallization difficult. Germ. Pat. 141670 has for its object the preparation of a crystalline soda alum: exactly neutral solutions of the two sulphates (40 — 43° Bé.) are mixed and cooled in crystallizing vessels. At first

an amorphous mass is formed which becomes crystalline after some days. The formation of the crystals is hindered by even minute quantities of acid. Since the crystals do not effloresce, no alteration in the aluminium content takes place, and the alum is valuable for dyeing purposes. According to supplementary Germ. Pat. 178236 the necessary degree of concentration can be obtained by dissolving both materials in hot water. On cooling, the soda alum separates in the crystalline form; the separation is facilitated if the solution is made *basic*, e. g. by the addition of basic aluminium sulphate.

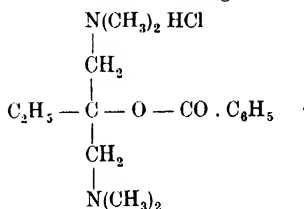
4. CHROME ALUM. $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24 H_2O$. It differs from potash alum in that the Al is replaced by Cr. It is obtained in large quantities as a by-product in the manufacture of anthraquinone (q. v.).

Chrome alum forms large, dark-violet octahedra, sparingly soluble in cold, readily in hot water. It is used as a mordant in dyeing, for the preparation of leather and water-proof fabrics, to render glue and rubber insoluble, &c.

Aluminium sulphate is frequently known commercially as 'Concentrated alum'. See ALUMINIUM COMPOUNDS.

TEST. The Al is estimated by precipitating with NH_3 in presence of NH_4Cl ; the Fe is estimated colorimetrically with KCNS; alkali is only rarely estimated. For qualitative tests the usual methods are used.

Alypine. Is the hydrochloride of benzoyl — 1, 3 tetramethyldiamino — 2 — ethylisopropylalcohol and has the following constitution



Is a non-hygroscopic substance, forming beautiful crystals readily soluble in H_2O . M. P. 169° . The solution may be sterilised without decomposition. It is used in medicine as a substitute for cocaine, usually in 1—5% solutions.

Amalgams see MERCURY ALLOYS.

Amber (SUCCINUM). Is the fossil gum of an extinct coniferous species (*Pinites Succinifer*). It is principally obtained from "blue earth" by mining but is also collected on the shores in nets. Acid number 15—35; ester-number 71—91; saponification-number 86—145; percentage of H_2O 1%; percentage of ash 0.2—0.3%.

Amber is found in pieces which are yellow, white, dark red or brown in colour. The different kinds recognized commercially are white, yellow, red, and waste products.

It is sparingly soluble in alcohol, ether, fats and volatile oils, when ignited it burns with a luminous flame and when heated in absence of air it forms a sublimate of succinic acid.

Olshausen and Rathgen have determined very carefully the fusion point of Baltic amber and found it to be between 348° — 384° (Zeitschr. f. Ethnologie 1904, Heft I).

Larger pieces of amber are used for ornamental purposes, cigar holders &c. It is also used in the manufacture of succinic acid and of varnishes.

Many imitations of amber are known, e. g. the so called artificial or American amber is made by melting and moulding different gums (e. g. copal, mastic, &c.)

By melting together the waste products of amber and amber dust the so-called melting amber or AMBROID is obtained.

If amber waste be powdered, extracted repeatedly with warm CHCl_3 or ether, and the solution thus obtained distilled there remains behind a yellowish-white residue a mixture of the α and β amber gums. According to the Germ. Pat. 160094, 25 parts of this mixture are mixed, after being freed from the last traces of the solvent, and ground on cooling, with 1000 parts of powdered copal resin and the mixture subjected to great pressure in a heated hydraulic press. On cooling, a homogenous product is obtained which may be worked like amber and is suitable for amber substitutes.

Ambergris (AMBRA GRISEA). A greyish brown opaque mass found floating on the sea as well as in the intestines of the spermwhale and is now considered to be the enterolith of the above named animal. Sp. Gr. 0.908—0.920. F. P. 60°C .; has a peculiar aromatic, musky odour; insoluble in H_2O , soluble in strong alcohol, ether, fats, and in essential oils. Used in perfumery. The high price accounts for the large number of imitations.

Ambroid see AMBER.

Amidoacetic acid see GLYCOCOLL.

Amidoazobenzene see AZO-COMPOUNDS.

Amidobenzene see ANILINE.

Amidobenzenesulphonic acids see BENZENE COMPOUNDS and SULPHANILIC ACID.

Amidobenzoic acids see ANTHRANILIC ACID and BENZOIC ACID.

Amidol see PHOTOGRAPHIC CHEMICALS.

Amidonaphthalene see NAPHTHYLAMINE.

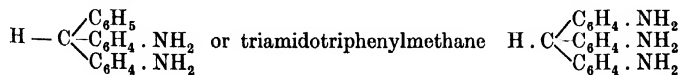
Amidophenols $\text{C}_6\text{H}_4(\text{OH})\text{NH}_2$. These are formed by the reduction of nitrophenols.

There are, however, other methods of formation: Para-amidophenol is prepared most easily. According to the Germ. Pat. 150800 it may be prepared from nitrobenzene in the presence of H_2SO_4 by an electrolytic process in which the electrodes are of carbon. The Germ. Pat. 154086 is a modification of this process in so far as dilute H_2SO_4 , in which nitrobenzene does not dissolve but merely floats on the surface, is used as the electrolyte.

o-Amidophenol melts at 170° . It is sparingly soluble in H_2O ; m-amidophenol melts at 122° while p-amidophenol melts (with decomposition) at 184° and at the same time sublimes.

p-Amidophenol is used as a photographic developer. See RODINOL under PHOTOGRAPHIC CHEMICALS.

Amidotriphenylmethane dyes. All dyes belonging to this class contain the chromophore $=\text{C}-\text{R}-\text{N}\equiv$ or $=\text{C}=\text{R}=\text{N}\equiv$. R represents either the phenyl, tolyl or xylol group, which is so disposed as to be in the para position to the N atom. One or two amido substituents occur as salt-forming groups in the two phenyl (or tolyl &c.) groups. The parent substance of these dyes is either diamidotriphenylmethane



or some alkyl substitution products. Malachite green, a salt of tetramethyl-diamidotriphenylcarbinol, for example, belongs to the first group. It is formed by condensing benzaldehyde with dimethylaniline in the presence of ZnCl_2 and oxidizing the product of the condensation with PbO_2 . The most important triamidotriphenylmethane dye is fuchsine (comp. article on FUCHSINE). The

amidotriphenylmethane dyes are a branch of the triphenylmethane dyes. (See these.)

Ammonal see SAFETY EXPLOSIVES.

Ammoniacum = Ammonia gum, see under GUM-RESIN.

Ammonia NH_3 . Colourless gas of Sp. Gr. 0.586; it has a sharp, penetrating smell and acts as a caustic. Very readily soluble in H_2O : 1 gr H_2O dissolves 0.679 grms NH_3 at 10°C . A solution of ammonia in water has properties very similar to those of the caustic alkalies, and to it a formula NH_4OH , is accordingly ascribed.

Ammonia is obtained on a commercial scale principally from the aqueous portion of the distillate produced in gas manufacture. In this it occurs partly in the free state and partly in the form of salts.

The principle of the recovery-process is the distillation of the aqueous portion with milk of lime. For this purpose different kinds of apparatus have been devised. Recently the so called "column apparatus" has been most largely used, chiefly on account of its automatic action. It should be observed that such apparatus must be made of cast iron since copper and brass are readily attacked by the vapour of ammonia.

Ammonia is also obtained from putrified urine, from animal waste products (e. g. the drainage from the slaughter-houses in Chicago) and also from distillers' waste. According to the Germ. Pat. 115462 and 137453 and 142505 ammonia is obtained by heating sea-mud either in a moist or in a dry state. To avoid overheating and secondary reactions the mud is first mixed with coal. The residue from the distillation forms a solid mass resembling coke. The Swedish Pat. 18653 (1903) describes a method for obtaining NH_3 from nitrogenous organic compounds (peat, dung, mud) by distillation with lime. In this process use is made of the heat developed when the quick lime is slaked.

The Germ. Pat. 125788 and 147558 protect a process for obtaining NH_3 (and glycerin as a by-product) from the residues left after the distillation of fermented mash.

The Germ. Pat. 151980 treats of the continuous production of ammonia from waste waters by blowing in a current of hot air. According to the Germ. Pat. 167022 ammonia is obtained from the gases obtained in dry distillation by passing them whilst hot without previously removing the steam and tar vapour, and in a finely divided state into concentrated acids, the temperature of which is kept about 80 – 85° . The tar then swims on the top of the acid and the solid salts formed can be removed.

The Germ. Pat. 157287 describes the preparation of ammonia by passing a mixture of nitric oxide and hydrogen over platinum sponge; the reaction is expressed by the following equation $2\text{NO} + 5\text{H}_2 = 2\text{NH}_3 + 2\text{H}_2\text{O}$. Commercially pure hydrogen is not used but a mixture of Dowson gas and water gas with nitric oxide. The reaction chamber must be cooled, for if the temperature rise above 80° ammonium formate, instead of NH_3 , is formed because CO is present in Dowson gas as well as in water gas. It is also expedient to expose the gas mixture to the action of silent electric discharges.

According to the Germ. Pat. 179300 NH_3 may be prepared from Dowson gas by the action of silent electric discharges. The mixture requires very careful cooling, the temperature not being allowed to rise above 80° . The best results are obtained when the mixture is kept between 65° and 80° .

For a long time experiments have been made with the object of making use of the nitrogen of the air and in recent years the experiments of A. FRANK have met with success (compare CALCIUM CYANAMIDE under CALCIUM COMPOUNDS and also CALCIUM NITRIDE). The mixture obtained according to the Germ. Pat. 108971 from the nitrogen of the air, consisting of cyanamide salts

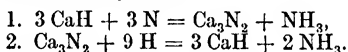
(e. g. Calcium cyanamide CaCN_2) is then treated according to the process described in Germ. Pat. 134289 with a view to obtaining NH_3 . For this purpose it is subjected to the action of steam or water under pressure. The reaction is expressed by the equation $\text{CaCN}_2 + 3 \text{H}_2\text{O} = \text{CaCO}_3 + 2 \text{NH}_3$. The Amer. Pat. 776314 of FRANK, by which cyanamide is heated under pressure in the presence of $\text{CO}_2 + \text{H}_2\text{O}$ to 100°C ., is almost identical with the previously mentioned patent.

The Germ. Pat. 146712 also aims at the synthetical preparation of NH_3 from air by passing the latter together with steam over red hot Fe_2O_3 , Bi_2O_3 or Cr_2O_3 ; NH_3 is formed and collected either as a gas or in the form of its salts. Instead of air other mixtures of N and O as well as coal gas or water gas can be used in this process.

Similar to this is the English Pat. 2200 (1903) (Amer. Pat. 776543.) A gas which contains H_2O , N and CO (e. g. Dowson gas or water gas) or a mixture of gases with air is exposed to the action of a silent electric discharge or brush discharge at a temp. below 80°C . in the presence of a porous catalytic agent. This process only differs from the above mentioned Germ. Pat. 157287 and 179300 in that air is expressly mixed with the gases.

The French Pat. 346066 describes the preparation of NH_3 by electrolysis. The gaseous mixture of N and O compounds obtained by electric discharges in the air is passed into a solution of a caustic alkali whereby nitrates and nitrites of the alkali metals are formed. By the electrolysis of these with insoluble electrodes and without a diaphragm ammonia is formed while the caustic alkali is regenerated and is again used. To obtain satisfactory results large cathodes must be used or a small amount of a soluble lead salt added to the electrolyte.

According to the French Pat. 350966 NH_3 is obtained from the nitrogen of the air by passing the latter over heated magnesium hydride or calcium hydride. It is carried out on a large scale by heating pure metallic Ca or Mg in a current of H until the hydride is formed, then shutting off the hydrogen and admitting N by means of which the hydride is converted into the nitride. H is again allowed to enter &c.; during the whole process NH_3 is being continually formed. If the formula for the hydride be taken as MgH (or CaH) and for the nitride Mg_3N_2 (or Ca_3N_2) then the different phases of the process are expressed by the following equations



According to the Germ. Pat. 175401 ammonia is prepared by passing air and water vapour heated to 300° into iron retorts containing peat at a temperature of 400° . In a modification (Germ. Pat. 176616) instead of the above-mentioned gas-mixture, air and water in the form of a spray may be used. In a still later modification (Germ. Pat. 180141) it is stated that other carbonaceous materials, such as coke, coal, brown coal and wood, may be substituted for peat.

The Germ. Pats. 181991, 181992 and 183702 describe a process for the preparation of ammonia in which atmospheric nitrogen is passed over a heated mixture of aluminium carbide and coal. Compounds of aluminium and nitrogen are formed which on treatment with water give NH_3 .

The purified and concentrated aqueous solution of ammonia (LIQUOR AMMONII CAUSTICI) contains up to 30 % NH_3 . In this state it may be used in ice machines. On account of its strongly alkaline properties ammonia is also used in large quantities in the manufacture of dyestuffs, in dyeing, calicoprinting and bleaching as well as for other purposes. Impure ammonia water is used in large quantities in the ammonia soda process, compare article on "SODA". Pure liquid ammonia may be now obtained in iron bombs. According to the Germ. Pat. 124976 ammonia may be prepared in a solid form

by dissolving 3—5 pts. sodium stearate at 40°C. in 95—100 pts. aqueous ammonia (containing 25—30 % NH_3). This "solid" ammonia gives up all its NH_3 on exposure to the air, more quickly on gentle heating. A small residue of sodium stearate remains behind.

The strength of aqueous solutions can be found from the Sp. Gr.

Compare the following table of LUNGE and WIERNIK.

Sp. Gr. at 15° C.	Per cent. NH_3	1 lit. contains gr. NH_3 at 15° C.	Sp. Gr. at 15° C.	Per cent. NH_3	1 lit. contains gr. NH_3 at 15° C.
1.000	0.00	0.0	0.940	15.63	146.9
0.998	0.45	4.5	0.938	16.22	152.1
0.996	0.91	9.1	0.936	16.82	157.4
0.994	1.37	13.6	0.934	17.42	162.7
0.992	1.84	18.2	0.932	18.03	168.1
0.990	2.31	22.9	0.930	18.64	173.4
0.988	2.80	27.7	0.928	19.25	178.2
0.986	3.30	32.5	0.926	19.87	184.2
0.984	3.80	37.4	0.924	20.49	189.3
0.982	4.30	42.2	0.922	21.12	194.7
0.980	4.80	47.0	0.920	21.75	200.1
0.978	5.30	51.8	0.918	22.39	205.6
0.976	5.80	56.6	0.916	23.03	210.9
0.974	6.30	61.4	0.914	23.68	216.3
0.972	6.80	66.1	0.912	24.33	221.9
0.970	7.31	70.9	0.910	24.99	227.4
0.968	7.82	75.7	0.908	25.65	232.9
0.966	8.33	80.5	0.906	26.31	238.3
0.964	8.84	85.2	0.904	26.98	243.9
0.962	9.35	89.9	0.902	27.65	249.4
0.960	9.91	95.1	0.900	28.33	255.0
0.958	10.47	100.3	0.898	29.01	260.5
0.956	11.03	105.4	0.896	29.69	266.0
0.954	11.60	110.7	0.894	30.37	271.5
0.952	12.17	115.9	0.892	31.05	277.0
0.950	12.74	121.0	0.890	31.75	282.6
0.948	13.31	126.2	0.888	32.50	288.6
0.946	13.88	131.3	0.886	33.25	294.6
0.944	14.46	136.5	0.884	34.10	301.4
0.942	15.04	141.7	0.882	34.95	308.3

Ammonia:

Brotherton & Co. Ltd., City Chambers, Leeds.

Standard Ammonia Co. Ltd., 85 Gracechurch St., London E.C.

Ammonia gum see GUM RESIN.

Ammonia soda see SODA.

Ammonia water see GAS WATER.

Ammonite see SAFETY EXPLOSIVES.

Ammonium compounds. The monovalent hypothetical group ammonium NH_4 behaves exactly like the alkali metals and unites with halogens as well as acid rests to form AMMONIUM SALTS. These salts are formed by the direct addition of NH_3 to the oxygen-acids and halogen acids. The bulk of the ammonium salts are obtained technically by the methods described under the article on Ammonia i. e. by the distillation of the gas liquors with lime. The gas is collected in acids.

1. AMMONIA see special article.

2. AMMONIUM ALUM see ALUMS.

3. AMMONIUM ACETATE $C_2H_3O_2 \cdot NH_4$. A solution can be obtained by neutralizing acetic acid with ammonia; on evaporating, however an acid, and not a neutral salt is obtained. The latter may be obtained by saturating warm glacial acetic acid with dry NH_3 or ammonium carbonate. It is without odour, readily soluble, with an unpleasant salt taste, used in medicine, while the acid salt was formerly used as a preservative for articles of food.

4. AMMONIUM BROMIDE NH_4Br . Obtained by neutralizing NH_3 with HBr or by carefully adding Br to freshly prepared $(NH_4)_2S$, removing the sulphur so formed by filtration, and evaporating the filtered solution.

According to the Germ. Pat. 138008 a concentrated solution of ammonium carbonate is saturated with bromine and then the mother liquor separated from the precipitated salts. It is again saturated with ammonium carbonate and bromine is again passed in. These operations are repeated until the percentage of Cl in the mother liquor necessitates a renewal. The principal advantage of this process is said to be that the precipitation of the bromide salt is brought about and the Cl compounds kept in solution without the necessity of evaporating the solution.

NH_4Br is a colourless salt much resembling sal-ammoniac and possessing a sharp salty taste, soluble in H_2O and alcohol, turns yellow and becomes acid when allowed to stand in the air.

5. AMMONIUM CARBONATE. The so-called sal volatile or spirits of hartshorn formerly prepared by the dry distillation of animal matters is now exclusively obtained by the sublimation of a mixture of equal parts of chalk and ammonium sulphate with about $\frac{1}{8}$ of the whole weight of charcoal powder. It is a mixture of ammonium bicarbonate $NH_4 \cdot HCO_3$ and ammonium carbonate $CO(NH_2)_2 \cdot O \cdot NH_4$. Of late years also produced by the action of CO_2 on NH_3 gas (in a certain ratio) in the presence of steam.

Crystalline white transparent mass which gives off NH_3 in the air and absorbs H_2O . It volatilizes without decomposition at 60° ; 1 part salt is soluble in 4 parts H_2O at 15° , and in 1.6 parts at $60^\circ C$. Used in dye works, for cleaning clothes &c. (removing fat), and in medicine.

6. AMMONIUM CHLORIDE (SAL AMMONIAC) NH_4Cl . It is manufactured commercially solely from the NH_3 in the gas liquors and the distillation products of animal matters. The NH_3 vapour expelled from the gas-liquors after the addition of lime, is caught in HCl solution. It is better, however, to neutralize conc. ammonia water with HCl . Sal ammoniac is also a secondary product in the Solvay soda process (see under SODA). The manufacture of NH_4Cl by decomposing $(NH_4)_2SO_4$ with KCl seems to be attaining importance. The purification of NH_4Cl is generally carried out by recrystallization or sublimation.

Crude sal ammoniac is yellow, the pure salt white; crystallizes in small octahedra or cubes Sp. Gr. 1.522; odourless and of a sharp salty taste. 100 pts. H_2O dissolve 32.8 pts. at 10° , 72.8 pts. NH_4Cl at 100° . Formerly much more used than now. It is used in the manufacture of ammonium compounds and dyes, in cloth printing, soldering and in the tinning and zincing of Cu and Cu alloys &c.

Chloride of ammonium:

Willy Manger, Dresden, Germany.

7. AMMONIUM CHROMATES. a) Ammonium chromate $(NH_4)_2CrO_4$. Obtained by supersaturating a CrO_3 solution with NH_3 and evaporating the liquid; forms yellow crystals of pungent taste, readily soluble in H_2O . According to the Germ. Pat. 143320 and 146691 ammonium chromate is obtained by electrolyzing the solution of any ammonium salt, using a diaphragm, and an anode of chromium or chromium alloy. An insoluble anode may however also be used instead of the Cr anode, but in this case the electrolyte must

Blücher.

consist of a mixture of chromium sulphate and ammonium sulphate, which is kept alkaline by the addition of lime.

b) Ammonium bichromate $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$. Can be obtained by adding the required amount of CrO_3 to the neutral salt. Commercially however it is obtained directly by heating chrome-iron stone with lime in a furnace. CaCrO_4 is formed; this is converted by H_2SO_4 into CaCr_2O_7 , and this salt is decomposed with an ammonium salt, forming $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$. According to the Germ. Pat. 143251 in the electro-metallurgy of chrome-iron stone use is made of such oxidizing agents as are not decomposed by hot dilute H_2SO_4 (e. g. PbO_2 , MnO_2 , KMnO_4 &c.); these oxidizing agents can be regenerated by the electrolysis of the solution. According to the English Pat. 2223 (1903) the calcium chromate, obtained in the metallurgy of chrome ores, is washed with H_2O and treated with $\text{NH}_3 + \text{CO}_2$; the ammonium chromate formed is treated until the half of the NH_3 is expelled and ammonium bichromate separates out.

$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ forms red monoclinic crystals which are three times as soluble in H_2O as $\text{K}_2\text{Cr}_2\text{O}_7$. It is, however, not so cheap as the latter. On heating pure Cr_2O_3 is obtained.

8. AMMONIUM CYANIDE $\text{NH}_4 \cdot \text{NC}$. According to the Germ. Pat. 132916 valueless zinc ores of suitable kind (e. g. Galmei) are dissolved in dilute NH_3 and into this ammoniacal solution the gases from coke-furnaces or impure coal gas is passed; the zinc is thus precipitated as ZnS . Besides this, zinc cyanide is also formed, for the impure gases also contain cyanide compounds; the zinc cyanide is however decomposed by the H_2S , so that finally ammonium cyanide is obtained as a secondary product in the manufacture of ZnS . Other methods are also to be found under potassium cyanide (see POTASSIUM COMPOUNDS); most of the methods there described can be used for the preparation of ammonium cyanide, by making the necessary modifications.

9. AMMONIUM FLUORIDE NH_4F . Obtained by the action of NH_3 on HF or by the sublimation of a mixture of $\text{NH}_4\text{Cl} + \text{NaF}$. Deliquescent crystals very easy to sublime, etch glass even in the dry state. On heating NH_3 is driven off and the still more powerful acid salt $\text{NH}_4\text{F} \cdot \text{HF}$ remains behind. This salt is principally used for etching glass.

10. AMMONIUM FORMATE $\text{HCO}_2 \cdot \text{NH}_4$. According to the English Pat. 2200 (1903) it is obtained by exposing a gas, which contains H , O , N , and CO (e. g. Dowson gas or watergas), or a mixture of gases with air, to the action of silent electric discharges or brush discharges in the presence of a porous catalytic agent at a temp. above 80°C . (this results of itself if the mixture is not cooled). At a temp. lower than 80°C . NH_3 is formed by the same process. The Amer. Pat. 776543 and the Germ. Pat. 157287 are quite similar to this and are described under AMMONIA. In both NH_3 is formed when the apparatus is cooled, and ammonium formate when the apparatus is not cooled. Ammonium formate may also be obtained by double decomposition with other salts (e. g. from the calcium salts).

Carbonate of Ammonia:

Forbes, Abbott & Lennard Ltd., 85 Gracechurch St., London E.C.

11. AMMONIUM MOLYBDATE $(\text{NH}_4)_6\text{Mo}_7\text{O}_{21} + 4 \text{H}_2\text{O}$. Obtained by very gently evaporating the solution of molybdic acid in NH_3 . It forms large crystals readily soluble in H_2O which do not decompose in the air but give off NH_3 and H_2O on heating.

12. AMMONIUM NITRATE $\text{NH}_4 \cdot \text{NO}_3$. It is obtained commercially almost entirely by passing NH_3 vapour into HNO_3 . The deliquescent salt is separated from the mother liquor in the centrifugal machine and packed in air-tight cases. In recent years other modes of formation have been discovered. Thus it may be obtained (according to the Germ. Pat. 149026) by the reaction between ammonium sulphate and sodium nitrate. Care must however be

taken that the latter is present in great excess. The reaction can take place either in aqueous solution or by carefully melting together the two salts in the solid state. The Germ. Pat. 166746 and 184144 describe similar methods of preparation. According to the Amer. Pat. 754668 a mixture of lead or a lead compound and hydrofluosilicic acid of Sp. Gr. 1.80 is heated and a nitrate is added to the solution of lead silicofluoride thus obtained. Finally the $\text{Pb}(\text{NO}_3)_2$ is decomposed with NH_4F .

According to the Germ. Pat. 177172 and 178620 highly concentrated solutions of the nitrates of the alkalis or alkaline earths are treated with a mixture of gases containing ammonia and CO_2 (e. g. those produced in coal distillation). It is important that all H_2S should first be removed by treatment with iron oxide. Germ. Pat. 166427 describes the preparation of NH_4NO_3 free from nitrites.

Colourless crystals of bitter taste, extremely readily soluble in H_2O . Melt between 150° and 160° . It is used as a freezing salt (for making ice), for the manufacture of N_2O (laughing gas) as well as in blasting.

13. AMMONIUM OXALATE $(\text{NH}_4)_2\text{C}_2\text{O}_4$. Obtained in colourless crystals by saturating a solution of oxalic acid with NH_3 and evaporating. Crystals are soluble in about 20 parts of H_2O and decompose on heating with the formation of oxamide $(\text{CONH}_2)_2$. If an equivalent amount of oxalic acid be added to a solution of the salt, and then the liquid evaporated until it crystallizes, ammonium binoxalate (acid ammonium oxalate) $\text{NH}_4 \cdot \text{HC}_2\text{O}_4$ is obtained.

According to the Germ. Pats. 111078, 144150 and 161512 it might be conceivable that ammonium oxalate could be obtained directly by heating ammonium formate; the process however in the case of the ammonium salt seems not to be advantageous. The second of the above mentioned patents provides for the addition of ready made ammonium oxalate on heating, and the third for the addition of alkali, which is said to simplify the reaction and increase the yield.

14. AMMONIUM PERCHLORATE NH_4ClO_4 . The preparation is similar to that of potassium perchlorate (see No. 25 under POTASSIUM COMPOUNDS).

15. AMMONIUM PERSULPHATE $(\text{NH}_4)_2\text{S}_2\text{O}_8$. Obtained by the electrolysis of $(\text{NH}_4)_2\text{SO}_4$ in H_2SO_4 . For details see under PERSULPHATES. 100 pts. H_2O dissolve 58 pts. of salt at 0° . A solution of ammonium persulphate in H_2SO_4 is used under the name of CARO's Reagent (see article on REAGENTS).

16. AMMONIUM PHOSPHATE $(\text{NH}_4)_2\text{HPO}_4$. Obtained on a commercial scale by passing NH_3 vapour into conc. H_3PO_4 and evaporating the solution. Large colourless crystals of salty taste, readily soluble in H_2O . The salt gives off NH_3 in the air and gradually changes into the acid (primary) salt $(\text{NH}_4)\text{H}_2\text{PO}_4$. It has been used in recent years as an excellent manure.

17. AMMONIUM SULPHATE $(\text{NH}_4)_2\text{SO}_4$. It is chiefly obtained from GAS LIQUORS (see this) either by treating the latter directly with H_2SO_4 and evaporating the liquid, or by driving off the NH_3 after adding lime, and then passing the vapours into H_2SO_4 . In the first case, the adhering brown tarry matter must be removed either by drying the salt on heated plates, or by dissolving it again and filtering it through animal charcoal. It is also obtained from putrified urine, and from the ammonia waters of the bone charcoal factories, and as a secondary product in other processes. English Pat. 20837 (1905) protects a process by which it is recovered in cyanide manufacture.

It forms colourless crystals of sharp salty taste, insoluble in alcohol. They contain no water and do not decompose in the air. 100 pts. H_2O dissolve 71 pts. at 0° and 97.5 pts. at 100° . It is used as a manure, for the manufacture of ammonia and other ammonium salts.

18. AMMONIUM SULPHIDES. Ammonium sulphide $(\text{NH}_4)_2\text{S}$ is obtained in clear, glistening, readily soluble crystals by the action of 1 mol. H_2S on two

mols. NH_4OH at a very low temp. Exposed to the air they lose NH_3 and are converted into ammonium hydrosulphide $(\text{NH}_4)\text{HS}$. The latter (the real ammonium sulphide) can also be obtained in the form of a solution by passing H_2S into a solution of ammonia at the ordinary temperature. It is obtained commercially by the distillation of sal-ammoniac and potassium sulphide or by heating a mixture of $(\text{NH}_4)_2\text{SO}_4$ or NH_4Cl and gas lime or soda residues with steam and condensing the ammonium sulphide in cooling chambers.

Cryst. ammonium pentasulphide $(\text{NH}_4)_2\text{S}_5$ may be obtained, according to BYERS, by adding 95 % alcohol to an equal vol. of a concentrated ammonium sulphide solution which has been saturated with S and allowing the mixture to stand several hours. The pentasulphide separates out in orange red prisms.

19. AMMONIUM SULPHOCYANIDE NH_4CNS . With regard to the manufacture of the crude salt see under SULPHOCYANIDE COMPOUNDS. The pure salt is obtained from the former by recrystallization, or better by precipitating the $(\text{NH}_4)_2\text{SO}_4$ which is always found in the crude salt, with $\text{Ba}(\text{CNS})_2$, pressing the precipitate and evaporating the lye until it crystallizes.

20. AMMONIUM TARTRATE. Besides the neutral salt $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$ an acid salt is also known $(\text{NH}_4)\text{C}_4\text{H}_5\text{O}_6$. Obtained by the action of NH_3 on solutions of tartaric acid.

21. AMMONIUM VANADATE. By dissolving vanadic anhydride V_2O_5 in NH_3 , ammonium metavanadate is formed which is obtained on evaporation in the form of colourless crystals, free from water, insoluble in alcohol and sparingly soluble in H_2O . It is used in dyeing and in cloth printing. As it colours an infusion of gallnuts deep black it is used for making black ink.

22. AMMONIUM TIN CHLORIDE (Pink salt) see TIN COMPOUNDS.

23. AMMONIUM ZINC CHLORIDE (Soldering salt) see SOLDERING.

Ammonium Compounds:

Brotherton & Co. Ltd., City Chambers, Leeds.

E. S. Spencer Ltd., Drummond Road, London S.E.

Amperemeter see ELECTRICAL MEASURING INSTRUMENTS.

Amyl acetate (ACETIC ACID ISOAMYLESTER) $\text{CH}_3\cdot\text{COO}\cdot\text{C}_5\text{H}_{11}$. It is prepared by allowing a mixture of 100 pts. of anhydrous sodium acetate, 100 pts. fermentation amyl alcohol, and 130 pts. conc H_2SO_4 to stand 12 hours and then either distilling on the waterbath or separating the amyl acetate by the addition of H_2O . It is then washed and purified. Glacial acetic acid may also be used instead of sodium acetate. Amyl acetate is valued on account of its odour, which resembles that of pears, and is used under the name of "pear oil" in the manufacture of fruit essences.

Amyl acetate:

C. Erdmann, Leipzig-Lindenau.

Amyl alcohol $\text{C}_5\text{H}_{11}\cdot\text{OH}$. Of the 8 theoretically possible amyl alcohols, the inactive amyl alcohol (Iso-butyl carbinol or Iso-amyl alcohol) is the most important, as it is the chief constituent of fusel oil. The fusel oil obtained from potatoes contains a large amount.

It is prepared by shaking raw potato fusel oil with slightly alkaline water in order to remove the ethyl alcohol, separating the top layer (fusel oil), drying it with CaCl_2 and distilling it on the sand bath. The portion which distills over between 130° and 135° is collected and again rectified.

Pure amyl alcohol is a colourless oily liquid which boils at 129° — 131° and possesses a sharp taste and penetrating unpleasant smell Sp. Gr. 0.825 at 0° ; miscible with ethyl alcohol and ether, dissolves fats and gums and burns with a blue flame; 39 pts. H_2O dissolve 1 pt. amyl alcohol.

It is used for the preparation of fruit essences, amyl nitrite, valeric acid and different aniline colours; it is also used as a lighting material, and for the

preparation, purification of, and as a test for many alkaloids. Amyl alcohol is poisonous; even the vapours when inhaled are injurious. Compare article on FUSEL OILS.

With regard to the preparation of pure active amyl alcohol from molasses fusel oil see the note by MARCKWALD in the Ber. d. Deutsch. Chem. Ges. 35, 1595, 1902.

Rectifying apparatus for amyl alcohol:

Friedrich Hockmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Amyl nitrite $C_5H_{11} \cdot NO_2$. It is prepared by heating 10 pts. amyl alcohol with 2 pts. of starch to 100° and passing N_2O_3 through the liquid. The amyl nitrite distils over and is collected in a receiver cooled by ice. The distillate is neutralized with dry $Na \cdot HCO_3$ and dried with $CaCl_2$ and then rectified.

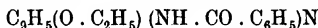
Clear, mobile, pale yellow liquid which boils at 97° — 99° C. and possesses a smell resembling that of various fruits. It is inflammable, insoluble in H_2O , readily miscible with alcohol, ether, chloroform and benzene. Sp. Gr. 0.877 at 15° C. It is used in medicine for head aches, epilepsy and asthma (inhaling the vapour). Great care must be exercised in its use.

Amyloform. Chemical compound of formaldehyde and starch. Nothing certain is known with regard to its preparation.

A white powder which swells up in H_2O and is used for treating and drying wounds. It is used as a specific for colds.

Amylum see STARCH.

Analgene (BENZANALGENE). o-Ethoxy-ana-benzoylamidoquinoline



The manufacture is protected by the Germ. Pat. 60308; the starting point is o-oxyquinoline.

White tasteless powder almost insoluble in H_2O sparingly soluble in cold but more readily in hot alcohol M. P. 208° .

It is taken internally for rheumatism, gout, nervous troubles &c. It reduces fever and causes perspiration.

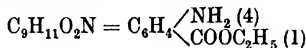
Analysis. See under the separate articles on ELECTROLYSIS, ELEMENTARY ANALYSIS, GAS ANALYSIS, COLORIMETRY, VOLUMETRIC ANALYSIS (also ALKALIMETRY) and SPECTROSCOPIC ANALYSIS.

Table of factors for the calculation of the analyses, see Appendix.

Analytical reagents:

Dr. C. L. Marquart, chem. Fabrik, Bouel a. Rhein (Germany).

Anaesthesine = p-Amidobenzoic acid ethylester of the following constitution

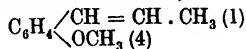


It is obtained from p-nitrobenzoic acid ethylester by reduction with $Sn + HCl$; white crystalline powder extremely light, sparingly soluble in H_2O readily soluble in alcohol, ether, benzene and fatty oils M. P. 90° — 91° .

It is an excellent local anaesthetic used for wounds of all descriptions, skin diseases, ulcers &c. It is taken internally as a soothing draught for vomiting and other digestive troubles. Used externally as a powder, and as a 5—20 % ointment mixed with dermatol and starch. Taken internally in doses of 0.2—0.5 grm. daily.

Anatto see VEGETABLE DYES.

Anethol (PROPENYLPHENOLMETHYLETHER)



The essential constituent of aniseed oil, prepared from it by repeated fractional distillation or separated by freezing. The synthetic preparation is not carried out on a commercial scale. M. P. 21.6, B. P. 232°. It serves as the starting point in the preparation of ANISALDEHYDE (q. v.).

Anhydride see SULPHURIC ACID ANHYDRIDE.

Aniline (AMIDOBENZENE, PHENYLAMINE) $C_6H_5NH_2$. It is prepared commercially by the reduction of nitrobenzene according to the equation $C_6H_5 \cdot NO_2 + 3 H_2 = C_6H_5 \cdot NH_2 + 2 H_2O$. The reducing agents are almost always $Fe + HCl$ and the reduction is carried out in vessels which are mechanically stirred and heated by steam. At the close of the reaction the acid is neutralized with lime and the aniline driven off with high pressure steam into a receiver where it collects under the water and is run off by means of a tap. If it is required absolutely pure it is redistilled; the rectification is now usually carried out *in vacuo*.

A new mode of formation of aniline and its homologues (Germ. Pat. 139457) is based on the reduction taking place in the presence of finely-divided metals: reduced Cu acts most favourably. If the vapour of nitrobenzene mixed with excess of H (or water gas) be passed over a layer of reduced Cu at a temp. of 300—400°, it is at once reduced to aniline. The metal suffers no alteration in this process and so may be used over and over again.

The electrolytical manufacture (protected by different patents) seems likely to be of practical importance. The nitro-derivatives are converted into the amines in the presence of metallic salts which are at the same time deposited on the cathode. By using Cu salts a yield of 80—90 % or more is obtained.

The Germ. Pat. 144809 describes an interesting process for the preparation of aniline and its homologues from the corresponding nitro-bodies.

The reducing agent is sodium disulphide Na_2S_2 ; the reaction is expressed by the equation $C_6H_5 \cdot NO_2 + H_2O + Na_2S_2 = C_6H_5 \cdot NH_2 + Na_2S_2O_3$. For example 240 pts. cryst. sodium sulphide, 32 pts. S, 200 pts. of H_2O are mixed in a boiler provided with a mechanical stirring apparatus and a reflux condenser. The whole is brought into solution by boiling and then 123 pts. $C_6H_5 \cdot NO_2$ are allowed to flow into the solution. After 12 hours boiling and stirring the reaction is finished. The lye and the oil can be easily separated after standing for a short time.

The aniline oil is then washed and purified in the usual way by distillation *in vacuo*. Sodium thiosulphate is obtained from the aqueous lye by evaporating and allowing it to crystallize. Pure aniline is a strongly refracting, colourless, liquid of peculiar smell. Sp. Gr. 1.0265 at 15°. B. P. 182°; it readily volatilizes with steam. It is readily soluble in alcohol, ether, and benzene, and to a slight extent in H_2O . It dissolves sulphur, phosphorus, camphor and many other substances. Besides the pure aniline of commerce the so-called aniline oils are used to a still greater extent; these are impure products which differ according to the nature of the nitrobenzene used in making them.

The following distinctions can be made.

1. ANILINE OIL FOR BLUE or BLUE ANILINE; almost pure aniline. Sp. Gr. 1.034—1.036, B. P. 180—190°.
2. ANILINE OIL FOR RED or RED ANILINE; a mixture of about 1 pt. aniline and 2 pts. para and orthotoluidine, B. P. 190—198°.
3. ANILINE OIL FOR SAFRANINE; a mixture of 35—50 % aniline and 65 to 50 % o-toluidine (sp. Gr. 1.032—1.034). It is distilled off from the fuchsine fusion; these waste products are termed *échappés* or fuchsine *échappés*.

Blue aniline is used for the preparation of methylaniline, dimethylaniline ethylaniline, diethylaniline, quinoline, quinaldine, induline, sulphanilic acid, fuchsine, aniline blue, aniline black, many azo-dyes &c.

Red aniline is principally used for the manufacture of fuchsine; aniline for safranine, as indicated by the name, for the preparation of safranines.

ANILINE SALTS. $C_6H_5 \cdot NH_2 \cdot HCl$. The hydrochloride of aniline. It is obtained by saturating aniline at 100° with HCl (free from Cl_2). After standing a few days the salt separates out. It is then freed from the mother liquor in a centrifugal machine and dried at 50° . It is used in large quantities for dyeing black on cotton.

Aniline:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

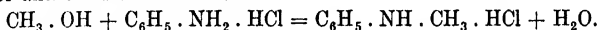
Rectifying apparatus for aniline:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Aniline derivatives. Only the most important derivatives and those which are closely related to aniline, are given here. The others have been treated separately or are classed under different articles.

a) METHYLANILINE DERIVATIVES.

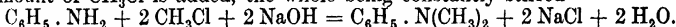
1. **MONOMETHYLANILINE** $C_6H_5(NH)CH_3$ obtained by heating methylalcohol and aniline salt to 200°



The methyl alcohol used must be free from acetone. The reaction takes place in autoclaves made of enamelled cast iron. An attempt has also been made to manufacture this substance electrolytically French Pat. 334726.

Colourless liquid (Sp. Gr. 0.976 at $15^\circ C$). B. P. 191° .

2. **DIMETHYLANILINE** $(C_6H_5 \cdot N(CH_3)_2)$ is either prepared as in the case of monomethylaniline (using however twice the amount of methyl alcohol) or more commonly by the action of methyl chloride on aniline. A mixture of aniline and $NaOH$ is heated in an autoclave (fitted with a stirring contrivance) to 100° under a pressure of 5–6 atmospheres and then the required amount of CH_3Cl is added, the whole being constantly stirred



At the end of the reaction the dimethylaniline is driven off with steam and purified by rectification (fraction 198 – 205°).

Colourless liquid, Sp. Gr. 0.9553 (at 15°). M. P. $+5^\circ$. Boil pt. 192° .

3. **p-NITROSODIMETHYLANILINE** $C_6H_4 \cdot N(CH_3)_2 \cdot NO$. Is obtained according to an earlier process by the action of N_2O_3 ($NaNO_2 + HCl$) on dimethylaniline.

Green plates which may be partly volatilized in steam. M. P. 92 – 93° .

b) ETHYLANILINE DERIVATIVES.

1. **MONOETHYLANILINE** $C_6H_5 \cdot NH(C_2H_5)$. Obtained in the same way as monomethylaniline.

Colourless liquid Sp. Gr. 0.954 (at $15^\circ C$). B. P. 204° .

2. **DIETHYLANILINE** $C_6H_5 \cdot N(C_2H_5)_2$ prepared in the same manner as dimethylaniline.

Colourless oil. Sp. Gr. (at 15°) 0.937. B. P. 213.5° .

For the remaining aniline derivatives see **DIPHENYLAMINE** and **METHYLDIPHENYLAMINE** under **DIPHENYLAMINE**. **NITRANILINE**. **PHENYLENEDIAMINE**. **AMIDOBENZENESULPHONIC ACID** under **BENZENE COMPOUNDS** and **SULPHANILIC ACID**.

All the aniline derivatives are used more or less for the manufacture of dyes and also partly for making pharmaceutical and other preparations.

Aniline colours see **COAL TAR DYES**.

Aniline black. A coal-tar dye of unknown constitution, of great importance on account of its use in cotton dyeing. It is formed by the oxidation of acid aniline salt solutions with MnO_2 , PbO_2 , KMnO_4 , with chromates, KClO_3 , ferric salts &c., especially in the presence of small amounts of Cu and vanadium compounds, which act as oxygen carriers. It has the formula $(\text{C}_6\text{H}_5\text{N})_x$.

On account of its insolubility, the aniline black is formed directly on the fibre by dipping the latter into a mixture of aniline salt and oxidizing agent and causing the oxidation by means of "steaming".

Ready made aniline black in the form of paste is used for cloth printing.

It is a mixture of salts (mostly chromates); the base is termed NIGRANILINE. Of recent years aniline black has also been manufactured by the electrolysis of aqueous aniline salt solutions (using electrodes of platinum or carbon). It is obtained on the anode. The sulphonated dye is then reduced by means of the electrolytically formed H to ANILINE WHITE which is used in the dyeing vat.

For vegetable fibres aniline black still takes the most prominent position amongst all black dyes. With regard to its different uses the last few years have brought such numerous innovations and improvements that they can not even be alluded to in this place. We refer our readers to the excellent special work by NOELTING & LEHNE "Anilinschwarz und seine Anwendung in Färberei und Zeugdruck."

Animal charcoal. By this term is meant all charcoal obtained by the ignition of animal substances with the exclusion of air. We may distinguish bone-charcoal, blood-charcoal, and flesh charcoal.

Animal charcoal manufacturing plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Animal dyes.

1. ALKERMES see No. 9 KERMES.

2. CARMINE see No. 3 COCHINEAL.

3. COCHINEAL. A dye which consists of the dried bodies of the female shield louse *Coccus Cacti*. The wingless females which are bred on different kinds of cactus are collected and killed by means of boiling water, steam, or dry heat and then brought into commerce as oval bodies 1—2 mm long. A difference is made between the silver-grey and the black cochineal according as the bodies have lost or retained the white coating of wax. The dye in cochineal is carmine or carminic acid.

Besides cochineal itself, a red dye, carmine (cochineal carmine) also comes into commerce and is a delicate powder obtained by precipitation of a cochineal decoction with acid or an acid salt. The method of manufacturing carmine is kept secret; usually it is an aluminium-lime albuminate of carminic acid. Carmine lake is also obtained from cochineal and is known under the names FLORENTINE LAKE, VIENNA LAKE and PARISIEN LAKE. It is obtained by precipitating alkaline cochineal solutions with alum or with alum and tin salt. By digesting powdered cochineal with NH_3 (with exclusion of air) and precipitating the resulting solution with aluminium nitrate the COCHINILLE AMMONIACALE is obtained which comes into commerce in dark brown tablets. Finally cochineal is pressed into the form of cakes and is then known as COCHINEAL CAKE.

Carmine and carmine lake are used as water colours and oil colours; it is now only very rarely used for dyeing wool (with Al_2O_3 or tin mordants).
COCHINEAL

4. EUXANTHINIC ACID see No. 14 PURREE.

5. DYER'S LAKE see No. 11 LAC DYE.

6. FLORENTINE LAC see No. 3 COCHINEAL.
7. INDIAN YELLOW see No. 14 PURREE.
8. CARMINE and CARMINE LAC see No. 3 COCHINEAL.
9. KERMES (ALKERMES; KERMES BERRIES; SCARLET CORNS). The dried females of the shield louse, *Coccus Illcis*, which are brought into commerce as brown red corns as big as peas. They contain a red dye, related to carmine, which is used in Turkey for dyeing head gear (Fez). Kermes is no longer used for other purposes.
10. COCHINILLE see No. 3 COCHINEAL.
11. LAC-DYE (DYER'S LAC). A dye which is also derived from a shield louse *Coccus Lacca* (*Coccus Ficus*). The insects which live in the East Indies on the twigs of different species of *Ficus* are covered by the latex of the plants, which flows out when the insects insert their stings, and then hardens, forming a dark red gum. These twigs covered with gum form the stick-lac (with 10 % dye). The gum which has crumbled off and generally contains much less dye is termed corn-lac (with 2.5 % dye). The red dye which can be extracted from the gum with H_2O is used exclusively for dyeing wool. It is dissolved in HCl and alumina or tin oxide is used as a mordant. The gum after being freed from dye is SHELLAC.
12. LACK-LACK see No. 11 LAC-DYE.
13. PARISIAN LAC see No. 3 COCHINEAL.
14. PURREE (INDIAN YELLOW). A dye exported from India and China. It is obtained from the urine of cows which have been fed with mango leaves. By this method of feeding, the yellow gall-dye is increased. Purree, the dyeing constituent of which is the magnesium salt of euxanthinic acid, is used for making the painter's colour INDIAN YELLOW (JAUNE INDIEN).
15. SCARLET CORNS see No. 9 KERMES.
16. SEPIA (SEPIA BROWN). A dye obtained from the ink-sac of the cuttle fish (SEPIA). The contents of the sac are dissolved in NaOH and the filtered solution precipitated with acid. After the precipitate has been washed out it is mixed with a solution of gum and moulded into little blocks. Sepia is a water colour.
17. VIENNA LAC see No. 3 COCHINEAL.

Animal fibres see articles on SILK and WOOL.

Animal oil (OLEUM ANIMALE) is a dark brown oil obtained by the dry distillation of animal matter, more especially bones. It contains pyrrol and is especially rich in pyridine bases. Used for denaturing spirits.

Anisaldehyde (AUBEPINE, PHENOL 4-METHYLAL-1-METHYLETHER)



Prepared by the slow oxidation of anethol (q. v.) with a solution of 2 parts $K_2Cr_2O_7$ and 3 parts sulphuric acid in $8\frac{1}{2}$ parts of water. At the end of the reaction the mixture is distilled with steam and the oily part of the distillate purified by treatment with a bisulphite solution.

A colourless oil having a strong smell of hawthorn. Of late it has been largely used in perfumery.

Aniseed oil (OLEUM ANISI). Volatile oil obtained from aniseed (*Fructus Anisi*) the fruit of *Pimpinella Anisum*, by distillation with H_2O . The different species of this fruit contain between 1.9 and 3.5 % of the oil.

Colourless or pale yellow, peculiarly aromatic-smelling volatile oil of a sweet spicy taste S. G. (at 15°) 0.980—0.990. It becomes solid at 14° — 19° . B. P. 222° — 228° . Iodine number 186—274. Potash absorption 0.25—0.38 %. It consists of 80—90 % anethol (ANISEED CAMPHOR) which is considered the effective aromatic principle of aniseed oil. Aniseed oil (just as the recently

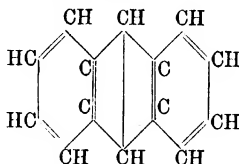
isolated anethol itself) is much used in perfumery and in the manufacture of liqueurs and is adulterated in many ways. The adulterations consist partly in mixing with inferior kinds and partly in the addition of other substances, especially STERN ANISEED OIL.

Anisidine (METHOXYANILINE). Methylether of amidophenol $\text{CH}_3 \cdot \text{O} \cdot \text{C}_6\text{H}_4 \cdot \text{NH}_2$. o anisidine an oil S. G. 1.108 is derived from o amidophenol and boils at 226.5° under a pressure of 734 mm. P anisidine is obtained from p nitrophenolmethylether (p nitranisol) by means of $\text{Sn} + \text{HCl}$. It crystallizes in tablets M. P. 55.5° — 56.5° .

Ankylotaphine. This is the name given to a disinfectant containing about 15 % creosol which has recently been brought into the market and is intended as a disinfectant for miners' worm disease (Ankylostomiasis).

Anthion see PHOTOGRAPHIC CHEMICALS.

Anthracene $\text{C}_{14}\text{H}_{10}$. Is a hydrocarbon of the constitution;



which occurs in coal-tar and is obtained from the higher boiling portion of the same, that fraction which boils above 270° being collected separately and known as anthracene oil.

Anthracene oil is a yellow-green buttery mass containing numerous crystalline scales. S. G. 1.085—1.095. It contains about 3 % anthracene. Formerly the amount was considered to be about 20 % but it has now been shown that phenanthrene, fluoranthrene, carbazol, pyrene and other hydrocarbons are also found in it. The main constituents of the mixture of hydrocarbons known as anthracene oil have not yet been scientifically investigated.

In order to prepare anthracene the oil is allowed to stand several days in a cool place (eventually using artificial cooling) and then the liquid is removed from the crystals in the centrifugal machine or in a filter press. The crude product thus obtained is then more strongly pressed in a hydraulic press, which towards the end is heated.

The crude anthracene thus obtained with a percentage of 25—40 % is then treated with solvents especially SOLVENT-NAPHTHA with a view to removing the impurities.

The complete purification of the anthracene is carried out by subliming it with high pressure steam. The early Germ. Pat. 111359 in which the crude anthracene was melted and then allowed to partly crystallize, the crystals being then treated with melted caustic alkali and finally with benzene, has been allowed to expire and therefore does not seem to have given satisfaction.

The French. Pat. 335013 seems to be a modification of this process. According to this the crude anthracene is first completely melted (100%) and then allowed to cool down to 50° . This crystal mass is then drained from the liquid and the last traces of the latter removed in the centrifugal machine. In this way 40—50 % anthracene is directly obtained. The French Pat. 349337 also seems to have proved a failure. Here the raw anthracene was treated with conc. H_2SO_4 in the presence of a solvent like naphtha CS_2 , or CCl_4 , in which it is insoluble.

Numerous other methods have also been recommended for purifying anthracene but it is not known whether they have proved valuable. Anthra-

cene may be obtained specially pure by recrystallization from pyridine. The Germ. Pat. 68474 uses liquid SO_2 for purifying it, while the Germ. Pat. 113291 lixiviates the crude anthracene with liquid ammonia in a closed apparatus under pressure which is said to dissolve chiefly the impurities.

According to the Germ. Pat. 141186 the raw anthracene is not separated from the anthracene oil because the latter is a good solvent for the impurities. The strained oily mass of anthracene is treated with the common solvents (petroleum ether, acetone, benzene, pyridine &c.) so that a mixture of these with $\frac{1}{2}$ pt. anthracene oil i. e. an oil which boils at about $200-380^\circ$ is used for purifying anthracene.

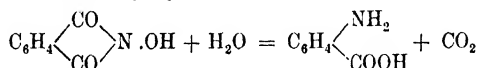
The English Pat. 17641 (1903) aims at the purification of anthracene by the so called „sweating method“ generally employed in the paraffin industry, i. e. by warming (almost to the melting point) the crude anthracene in blocks or lumps, on shelves which are perforated, the heating being performed by superheated steam. In this way the more readily melted impurities melt and flow away.

According to the Germ. Pat. 164508 a solution of crude anthracene in a solvent not miscible with H_2SO_4 is purified by treatment with conc. H_2SO_4 . The latter is removed and the anthracene separated.

Purified anthracene comes into the market as a loose bright yellow mass resembling snow in texture, about 60–90 % pure. It is generally used in this state for the manufacture of anthraquinone, alizarin and their derivatives. Absolutely pure anthracene forms small white glistening plates with a violet fluorescence M. P. 216.55° ; at a slightly higher temp. it readily sublims. B. P. above 351° ; insoluble in H_2O ; 1 pt. anthracene dissolves in 170 pts. alcohol 60 pts. carbon disulphide 110 pts. benzene, more readily in the higher homologues of benzene.

Anthracite see FUELS.

Anthranilic acid (o-Amidobenzoic acid) $\text{C}_6\text{H}_4(\text{NH}_2) \cdot \text{COOH}$. It is prepared by boiling phthalylhydroxylamine with alcoholic potash. The reaction is expressed by the following equation



Phthalylhydroxylamine is readily obtained (according to the Germ. Pat. 130680 and 130681) from phthalic acid anhydride and hydroxylamine. It has however been shown that the above mentioned reaction between phthalylhydroxylamine and alcoholic potash frequently does not take place, and the Germ. Pat. 130301 and 130302 substitute this process by a treatment with aqueous Na_2CO_3 or K_2CO_3 solution, the phthalylhydroxylamine being replaced by its alkali salt. Another process (Germ. Pat. 135836 and 136788) starts from the free phthalylhydroxylamine, which, on boiling with an aqueous solution of caustic alkali or alkali carbonate, produces a good yield of anthranilic acid. The phthalylhydroxylamine acid is formed at ordinary temperature by treating phthalic anhydride with an aqueous solution of hydroxylamine.

We may also mention Germ. Pat. 133950. The starting point in this is phthalchlorimide which is digested with dilute NaOH yielding anthranilic acid.

The Germ. Pat. 145604 protects a patent in which salts of o-chlorbenzoic acid are heated under pressure to 125° with aqueous NH_3 in the presence of Cu or Cu salts. In this way anthranilic acid is obtained, but if the NH_3 is replaced by aqueous solutions of monoalkylamines then anthranilic acids may be obtained in which the N is combined with alkyl rests.

Finally the Germ. Pat. 129165 and 138188 treat of a process in which o-nitrotoluene-p. sulphonic acid is converted by means of aqueous alkalies into

sulphoanthranilic acid $\text{CO}_2\text{H} : \text{NH}_2 : \text{SO}_3\text{H} = 1 : 2 : 3$ and this then turned into anthranilic acid by treatment with sodium amalgam. Boiling the o-nitrotoluenesulphonic acid with NaOH causes the simultaneous reduction of the nitro-group and the oxidation of the methyl-group so that sulphanthranilic acid is obtained. The o-nitrotoluene-p-sulphonic acid is obtained from p-toluenesulphonic acid which is a secondary product in the manufacture of saccharine. An improvement of the Germ. Pat. 129165, according to which the sulphanic acid is converted into anthranilic acid by means of sodium amalgam, is protected by the Germ. Pat. 146716. In this process the sulpho-group is split off by means of electrolysis in neutral or weakly acid solutions, using Hg or amalgamated cathodes.

Anthranilic acid melts at 145° ; it is used for the preparation of dyes and drugs. Anthranilic acid methylester is found in many essential oils and is now used for the preparation of artificial flower perfumes.

Anthraquinone. $\text{C}_6\text{H}_4 \begin{array}{c} \diagup \text{CO} \diagdown \\ \diagdown \text{CO} \diagup \end{array} \text{C}_6\text{H}_4$ is obtained from anthracene by oxida-

tion, potassium bichromate and dilute H_2SO_4 being used as oxidizing agents. The anthracene must be purified by sublimation and finely ground. The amount of bichromate to be employed depends on the purity of the anthracene (60—80 %). The reaction is carried out in a wooden vat lined with lead and fitted with a stirrer, capable of containing about 3000 l. 100—150 kg $\text{K}_2\text{Cr}_2\text{O}_7$ and 1500 l. H_2O are brought in, heated to boiling point by means of steam and then 100 kg anthracene are slowly added, the mixture being constantly stirred. — Afterwards dilute H_2SO_4 (30 Bé) is allowed to flow in. While the acid (140 — 210 kg) is being added, which takes about ten hours, the steam is shut off.

It is then boiled for a short time allowed to cool to a certain extent and the crude anthraquinone separated from the mother liquor. After being washed and dried it forms a reddish yellow powder (115—120 kg) which may be further purified by dissolving in hot concentrated H_2SO_4 . The further purification may be carried out with solvent naphtha or with pyridine bases. According to the Germ. Pat. 137495 this after-purification is better performed by nitrobenzene, aniline, or toluidine in which solvents the raw anthraquinone is soluble at the boiling point, and almost insoluble when cold. On cooling, the pure anthraquinone is deposited in crystalline needles which are then filtered off and washed with aniline oil.

The Germ. Pat. 160104 aims at the preparation of anthraquinone from anthraquinone α -sulphonic acid. Although according to the Germ. Pat. 149801 and 157123 the α -sulpho groups can be introduced into the anthraquinone nucleus by treating anthraquinone with sulphonating agents in the presence of Hg or Hg compounds; according to the new patent these groups can be split off again by heating the sulphonic acids to 190 — 200° in the presence of Hg or Hg salts with dilute H_2SO_4 .

According to the Germ. Pat. 152063 anthracene may be oxidized electrolytically to anthraquinone in acid solution in the presence of cerium compounds. The experiments of PERKIN and FONTANA (Elektrochem. Zeitschr. 1904, 99) confirm this patent. The electrolysis is carried out most advantageously in 20 % H_2SO_4 and salts of Cr or Mn may be used as oxygen carriers instead of those of cerium.

Pure anthraquinone forms bright yellow, long, flexible needles, M. P. 273° to 274° . It can be sublimed without decomposition, and boils above 360° . Insoluble in H_2O , sparingly soluble in alcohol and benzene. Readily soluble in cold conc. H_2SO_4 ; it can be precipitated unaltered from this solution by means of water.

With regard to its use see article on Alizarin.

Anthrarobine. (Dioxyanthranol). $\text{C}_6\text{H}_4 \begin{array}{c} \text{C(OH)} \\ \diagup \quad \diagdown \\ \text{CH} \end{array} > \text{C}_6\text{H}_3 (\text{OH})_2$. Obtained by

the reduction of alizarin with zinc dust and NH_3 .

Yellowish or yellow-brown, odourless powder, very sparingly soluble in cold H_2O more readily in hot H_2O , moderately soluble in boiling alcohol. It is used externally in skin diseases.

Anthrasol. A purified coal tar employed medicinally.

It produces no irritation. The method of purification is not at present known; a patent has been applied for. Later notices say that anthrasol contains in addition to the purified coal tar juniper-wood tar. Mobile, bright yellow oil with a smell of tar, in appearance resembling olive oil, miscible with absolute alcohol, acetone, fatty oils, paraffine &c.; it is used externally for itching skin diseases.

According to the experiments of BOKORNY (Chem.-Ztg. 1904, 990) its power as a disinfectant is not very great seeing that not even 0.1 % solutions can be prepared. The clinical experiences are however said to be very favourable.

Antibenzinepyrin is the name given in commerce to the magnesium salt of oleic acid used to lessen the inflammability of benzene.

Antibenzinepyrin:

Willy Manger, Dresden, Germany.

Antichlors. By this name is meant all those substances which are suitable for rendering innocuous the chlorine remaining after bleaching. Usually sodium thiosulphate (or hyposulphite, as it is commonly called) ($\text{Na}_2\text{S}_2\text{O}_3 + 5\text{H}_2\text{O}$) is used as an antichlor.

Thiosulphate is prepared technically by several different methods. For example by heating Na_2SO_4 with C, sodium sulphide is obtained and then SO_2 is passed into the aqueous solution of this salt. On a large scale however it is obtained from alkali waste which when allowed to oxidize forms a mixture with a high percentage of CaS_2O_3 . If this mass is then boiled with Na_2SO_4 the calcium thiosulphate is converted into $\text{Na}_2\text{S}_2\text{O}_3$.

In this last process the CaSO_4 formed cements together with the $\text{Na}_2\text{S}_2\text{O}_3$ and CaS_2O_3 , and the product is known under the name „precipitated antichlor“. It is preferably used in paper manufacture as it „fills“ the paper and at the same time acts as an antichlor.

Besides thiosulphate, also sodium bisulphite NaHSO_3 , hydrogen peroxide, and ammonia are used as antichlors.

Antifebrin see ACETANILIDE.

Antifriction metals. By this term is meant those metallic alloys which are chosen as material for bearings because they produce the smallest amount of friction.

The most common antifriction alloys are so called „white metals“. (Compare article on ANTIMONY ALLOYS.) Of the other antifriction metals we may mention that prepared electrolytically by RIEDER. A plaster of Paris cast, which has been made a conductor by being covered with graphite is made the cathode in a copper electrolyte.

After a layer of Cu has been deposited a second layer of graphite is put on, this is again covered with Cu, and so on. A copper plate is used as anode. The graphite reduces the friction, the metal is also suitable for dynamo brushes, stuffing boxes, piston-rod collar &c. (Chem.-Ztg. 1904, Repert. 16.)

The Germ. Pat. 148929 protects the manufacture of antifriction metals of Cu, Sn, Pb, Sb and Fe. The best results are said to be obtained by mixing

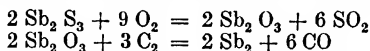
together cast iron and wrought iron in equal amounts and using the other metals in about the following proportions.

a) For bearings: 3 pts. Cu, 0.5 pts. cast iron 0.5 pts. wrought iron, 6 pts. tin, 75 pts. Pb, 15 pts. Sb.

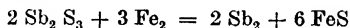
b) For coating the working surfaces of valves.

8 pts. Cu, 0.5 pts. cast iron, 0.5 pts. wrought iron, 19 pts. Sn, 60 pts. Pb and 12 pts. Sb. The metals are mixed in the given order, first the copper and cast iron are mixed then the wrought iron added in small pieces so that it quickly dissolves, then the rest are added one after the other, each being melted in a special crucible.

Antimony. Sb (STIBIUM) At. Wt. 119.9. It is obtained by roasting the antimony ore (antimony sulphide; grey antimony ore) in a furnace and reducing the antimony oxide thus obtained with charcoal according to the equations



According to another process the ore is freed from S without being previously roasted by heating it with metallic iron. To the latter Na_2SO_4 and C are added and in this way the separation of the metallic antimony from the iron sulphide is facilitated.



The Germ. Pat. 148894 introduces an alteration in this work of precipitation. In this process the Sb_2S_3 is not melted with Fe but the two substances are brought into a molten bath of iron sulphide, and allowed to react on each other. This sulphide bath serves to prevent waste of heat and covers the antimony ore, by which means the oxidation and volatilization of the antimony are diminished, while at the same time the heat of the bath is sufficient to allow the reaction to proceed.

According to the American Pat. 796849 the antimony ores are treated with 4 % NaOH at 50° and the antimony thus brought into solution. The latter is precipitated by CO_2 and Na_2CO_3 at the same time formed. The NaOH is then regenerated from the Na_2CO_3 by treating with lime.

The crude antimony is rather impure; it is refined by fusing it with a small amount of antimony sulphide and soda. A second purification follows without any fresh addition of materials.

Recently the methods for obtaining antimony electrolytically from its sulphur compounds have become important.

The SIEMENS-HALSKE process appears especially worthy of mention. A. G. BETTS has observed that solutions of FeCl_3 readily dissolve Sb_2S_3 with formation of FeCl_2 and SbCl_3 , leaving a residue of sulphur. On this he bases a method for extracting Sb by electrolysis the solution obtained as above. The anodes are of carbon and the cathodes of Pb or Cu. Metallic Sb separates and FeCl_3 is re-formed. The Sb falls to the bottom and is removed while a fresh supply of the electrolyte is added from above. A diaphragm is not necessary.

According to English Pat. 15294 (1904) the above method is considerably improved if the electrolyte is a solution of antimony trifluoride. This can be prepared by dissolving the roasted ore in HF. Both electrodes are of lead.

Pure antimony is a white metal glistening like silver. It crystallizes in coarse rhombohedra; very brittle and easily pulverised. S. G. 6.7—6.8 M. P. 430° . It is hardly acted on by the oxygen of the air at the ordinary temperature; combines directly with Cl, dissolves in aqua regia and is oxidized by HNO_3 .

Antimony is used widely in the form of its alloys (see ANTIMONY ALLOYS) on account of its property of hardening softer metals. (Pb and Sn &c.).

The commercial article known by the name **ANTIMONIUM CRUDUM** is not crude antimony, but antimony sulphide (Sb_2S_3). It occurs naturally in the form of gray antimony ore which is first liquated or melted in such a manner as to separate the sulphide from the rocky matter associated with it. This liquation is carried out either interruptedly in crucibles, or continuously in tubes.

The **ANTIMONIUM CRUDUM** is used in pyrotechnics for the preparation of white fire, also as a paint for ships, as a glaze for earthenware and for the preparation of pharmaceutical substances.

Antimonium crudum is also obtained by the wet method by boiling with HCl and passing H_2S into the antimony chloride solution thus obtained.

The antimony sulphide prepared by the wet method is used for vulcanizing caoutchouc.

The English Pat. 13579 (1904) describes a method for coating metals or metallic objects with antimony.

Antimony:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Antimony alloys. The property which antimony possesses of tending to increase the hardness of alloys and at the same time to render them more brittle and glistening causes its alloys to be of great importance. The most important are

1. **HARD LEAD (ANTIMONY LEAD).** Alloy of Pb and Sb in which the amount of Sb varies from 10—30 % or more. The commercial preparations contain from 8—10 % and from 16—18 % Sb . This amount is seldom exceeded. Its most important use is as type metal. In this case the proportion of Sb may not exceed 25 %, otherwise the alloy becomes too brittle. For this special purpose the addition of 10—20 % Sn and a little Cu (or Ni) and Bi greatly improves its properties. The Germ. Pat. 160994 protects an antimony-lead alloy containing a certain amount of sodium, which although of considerable hardness and great toughness is not brittle and can be worked well. An alloy has proved serviceable which contains 100 pts. Pb , 1.5 pts. Sb and 0.1 pt. Na .

2. **BRITANNIA METAL.** An alloy of Sn and Sb used for making house utensils (spoons, knife-handles, pots &c.). The alloy for this purpose generally consists of 90 % Sn and 10 % Sb , or better 90 % Sn , 8 % Sb and 2 % Cu . If the britannia is only to be cast (and not pressed or stamped) it contains more Sb and a little lead to facilitate the casting; for example 80 % Sn , 16 % Sb and 4 % Pb .

3. **WHITE METAL (ANTIFRICTION METAL).** An antimony tin alloy, like britannia metal, used for making bearings and stuffing-boxes. It is used because of the small amount of friction developed. The composition and constituents of this class of alloys vary widely; usually 70—90 % Sn , 8—15 % Sb , and 2—10 % Cu ; often more or less Pb is present.

One white metal for bearings, for instance, is made of 85 % Sn , 10 % Sb and 5 % Cu , another 52 % Sn , 46 % Sn , 0.4 % Sb and 1.6 % Cu ; a white metal for stuffing boxes contains 45 % Sn , 10 % Sb , 45 % Pb .

The Sp. Gr. of white metals ranges generally from 8—11. Formerly it was thought that the quality became worse the higher the Sp. Gr. because the latter was influenced by the amount of Pb present; however, of recent years white metals rich in lead have been preferred. For instance the metals used for bearings, glyco-metal, atlas metal, magnolin metal, myrtle antifric-metal, possess excellent qualities and have all nearly the same constitution and all contain about 78 % Pb .

Antimony colours.

1. **ALGAROTH** (Antimony oxychloride) $\text{Sb}_2\text{O}_3 \cdot \text{SbCl}_3$. Prepared by dissolving grey antimony ore in crude HCl and pouring the clear solution into

H₂O. The algaroth powder is precipitated as a heavy white precipitate which must be quickly washed and dried. Good white colour. The high price, however, prevents it from being widely used.

2. **ANTIMONY CINNABAR (ANTIMONY BLENDE, RED ANTIMONY)** Sb₂S₃O₃. Obtained by treating SbCl₃ with Na₂S₂O₃ in aqueous solution, within certain limits of concentration and proportions. On a commercial scale it is obtained by roasting antimony sulphide in a stream of air and steam, the Sb₂S₃ is partly converted into Sb₂O₃ and this is dissolved in HCl. It is a fairly stable red dye of great beauty, very little inferior to the real cinnabar; used especially in art painting.

According to the Germ. Pat. 160110 a brown antimony oxysulphide which can be used as a paint is obtained by heating the ores with an excess of C in a blast furnace.

3. Substitute for white lead. (ANTIMONY OXIDE) Sb₂O₃. It occurs naturally as white antimony ore and as antimony bloom; artificially obtained by roasting antimony sulphide. White paint with good covering power.

4. **NAPLES YELLOW** see under **LEAD COLOURS**.

Antimony compounds.

1. **ANTIMONIC ACID.** Antimonic anhydride Sb₂O₅ is obtained by oxidizing metallic antimony with fuming HNO₃. The true antimonic acid forms different salts most of which are derived from orthoantimonic acid H₃SbO₄, others from pyroantimonic acid H₄Sb₂O₇, and others from metantimonic acid HSbO₃.

2. **ANTIMONY FLUORIDE** SbF₃. Obtained by dissolving Sb₂O₃ in HF and evaporating. M. P. 292°. For some time it was used as a mordant. It has, however, been replaced by sodium antimony fluoride (see No. 11) and antimony salt (see No. 6).

3. **ANTIMONY OXALATE.** On adding oxalic acid to an acid solution of SbCl₃, the oxalate of the formula SbOHC₂O₄ separates out. It forms different double salts of which potassium antimonyloxalate is one. This generally passes under the name of antimony oxalate.

4. **ANTIMONY OXIDE** Sb₂O₃ (or Sb₄O₆). Occurs naturally as white antimony ore and antimony bloom. According to the American Pat. 704367, antimony oxide is obtained by roasting the broken-up antimony ore, oxidation and reduction taking place alternately, and treating the antimony vapours with steam. The process is said to allow of a convenient preparation of all antimony compounds through the medium of the oxide.

The Germ. Pat. 161776 protects a process for the preparation of Sb₂O₃ from antimony sulphide, in which the latter is treated with H₂SO₄ in the presence of alkali sulphate at 130° and the antimony alkali double sulphate extracted with H₂O.

Antimony oxide forms white crystalline needles which turn yellow when heated and volatilize above the melting point.

If Na₂CO₃ be mixed with SbCl₃ in aqueous solution, white amorphous antimonyhydroxide SbO . OH separates out. A series of salts (antimonyl compounds) is derived from this compound.

5. **ANTIMONY PENTACHLORIDE** SbCl₅. Obtained by saturating fused SbCl₃ with Cl₂. Strongly fuming yellow liquid M. P. —6°, very readily decomposable.

6. **ANTIMONY PENTASULPHIDE (Sulphur gold)** Sb₂S₅. If Sb₂S₃ be boiled with S and NaOH sodium thioantimonate (Schlippe's salt) Na₃SbS₄ + 9H₂O crystallizes out of the filtered solution. The solution of this salt is treated with HCl which precipitates antimony pentasulphide 2Na₃SbS₄ + 6HCl = Sb₂S₅ + 3H₂S + 6NaCl. The pentasulphide forms an orange red powder which is readily soluble in alkalis and alkali sulphides and decomposes into Sb₂S₃ and S on heating.

Sb_2S_3 was formerly much used in medicine but now only finds employment for vulcanizing and imparting a red colour to caoutchouc.

7. **ANTIMONY SALT.** Under this name are known different mixtures which are double salts of SbF_3 with alkali sulphates, or with alkali fluorides. They are obtained by different methods. Antimony fluoride is present in all.

Of late years they have been used on a large scale as mordants in dyeing and cloth painting and so are gradually displacing tartar emetic (see No. 10) mainly on account of their cheapness and solubility in H_2O .

Antimony salt must not be used in earthenware or glass vessels because these are attacked by the salt.

8. **ANTIMONY SULPHIDE; ANTIMONY TRISULPHIDE Sb_2S_3 .** See article on ANTIMONY.

9. **ANTIMONY TRICHLORIDE (ANTIMONY CHLORIDE, BUTTER OF ANTIMONY, SbCl_3 .** Obtained by distilling a solution of Sb_2S_3 in conc. HCl . Colourless crystalline plates of the consistency of butter. Obtained in solid glistening crystals by recrystallisation from CS_2 . M. P. 73° . B. P. 223.5° . Sp. Gr. (at 25°) 3.064. Delequiscient.

10. **POTASSIUM ANTIMONYLTARTRATE (TARTAR EMETIC) $\text{K}(\text{SbO}) \text{C}_4\text{H}_4\text{O}_6 + \frac{1}{2} \text{H}_2\text{O}$.** Prepared by precipitating SbCl_3 with H_2O and boiling the precipitate of SbOCl with soda solution. 4 pts. of the Sb_2O_3 thus obtained are dissolved in 5 pts. cream of tartar ($\text{KC}_4\text{H}_4\text{O}_6$) and 50 pts. H_2O . After being filtered the solution is evaporated to the point of crystallization.

Tartar emetic forms white crystals having a metallic and nauseating sweet taste, which effloresce in the air and are insoluble in alcohol. 1 pt. tartar emetic dissolves at 20° in 13 pts. H_2O , at 50° in 6 pts. H_2O . The sodium antimonyltartrate which is soluble in 2 pts. cold H_2O is also known under the name tartar emetic.

It is used in medicine as well as in dyeing.

11. **SODIUM ANTIMONY FLUORIDE SbF_3 .** NaF forms beautiful crystals readily soluble in cold H_2O . Even very dilute solutions do not decompose. Acid antimony fluorides (e. g. $\text{SbF}_3 \cdot \text{HF}$) are also known under the name antimony double fluoride.

Uses see Antimony salt.

Antinervine. A mixture of 50 pts. acetanilide, 25 pts. salicylic acid, and 25 pts. ammonium bromide.

It is prescribed for neuralgia, head-ache, bilious head-ache &c.

Antinonnin = o-Dinitrocreosolpotassium $\text{C}_6\text{H}_2(\text{OK})(\text{NO}_2)_2\text{CH}_3$.

A dye known also under the name of saffron substitute; it is however, no longer used as such. It is prepared according to NOELTING and de SALIS by converting nitro-o-toluidine into the diazo-compound, allowing the resulting diazotoluene nitrate to drop into boiling HNO_3 and neutralizing the precipitated dinitrocreosol with K_2CO_3 .

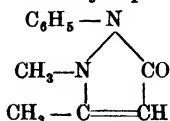
Seeing that, when dry, it is explosive, it is brought into the market in the form of a 50 % soapy paste. The 0.1 % aqueous solution is used with excellent results for spraying trees infected with the caterpillar of *Liparis monacha*.

Antinosine = Sodium tetraiodophenolphthaleine. It is the sodium salt of nosophene (see this).

Blue crystals which are readily soluble; used for treating wounds; given internally as a stomach disinfectant.

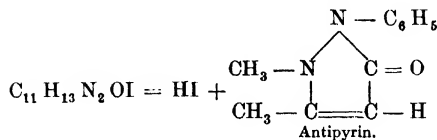
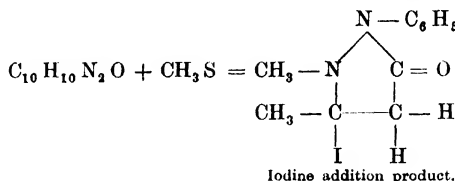
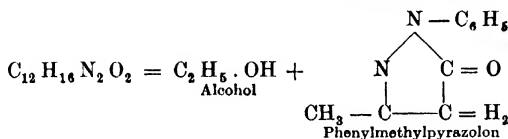
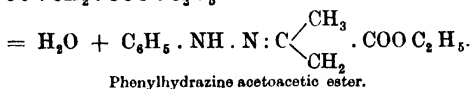
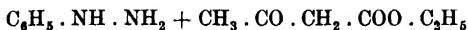
Antiputrol. This is the commercial name given to a yellowish brown, thick disinfectant which smells of tar and contains 65—70 % of phenols made soluble with soap.

Antipyrin (PARODYN). (2,3 Dimethyl-1-phenyl-5-pyrazolon)



It is prepared in different ways. The starting point is phenylhydrazine ($\text{C}_6\text{H}_5 \cdot \text{NH} \cdot \text{NH}_2$) and acetoacetic ester ($\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_2 \cdot \text{COO} \cdot \text{C}_2\text{H}_5$).

The phases of the preparation may be illustrated by the following equations



Antipyrin forms colourless and odourless crystals with a somewhat bitter taste M. P. 113°. It is soluble in less than 1 pt. H_2O , in the same amount of alcohol and chloroform, but only soluble in 50 pts. ether. It acts as a base and forms salts directly with acids.

It is a much valued drug for the treatment of fever, neuralgia and rheumatism. It is often prescribed in doses of 0.25—2grms daily.

One of its salts ANTIPYRIN MANDELATE is prescribed for whooping cough under the name of TUSSOL.

Antipyrinum amygdalinicum see TUSSOL.

Antipyrinum coffeino-citricum see MIGRÄNIN.

Antipyrinum salicylicum see SALIPYRIN.

Antiquities. Of late years different chemists have been devoting their energies to finding out some rational method of preserving antiquities of iron and bronze, amongst others FR. RATHGEN („Die Konservierung von Altertums-

funden, Berlin 1898), SETLIK („Über natürliche und künstliche Patina“ Chem.-Ztg. 1903, 454) and D. A. RHOU SOPULOS („Über die Reinigung und Konservierung von Antiquitäten“, (Chem. Zeitschr. 1903, 202, 364).

According to RATHGEN (Chem.-Ztg. 1903, 703), the preservation of antiquities may be attained in the four following principal ways. I. Preservation of the objects with the rust on them, by impregnating them with gum, varnish or paraffin, either with, or without, previous washing with water. II. Cleaning the objects by mechanically removing more or less of the rust or oxide. III. Removing the rust by dissolving it. IV. Removing the rust by reducing it to metal. One of the first two ways must be adopted if the metal is wholly or for the greater part converted into oxide. The third method is not to be recommended with bronzes as it is very difficult to wash the solvent (usually dilute HCl) entirely out of the interstices, with the result that the object is further attacked.

For iron objects however, BLELL's process of treating them with dilute H_2SO_4 has proved itself trustworthy. The last method, reduction, is the one which is nowadays generally carried out with objects which have a well preserved kernel of metal.

For iron objects, two methods are employed, either heating in a stream of hydrogen, or galvanic reduction. In the last mentioned method, the electric current is either produced outside the bath in which the reduction takes place or in the bath itself, by bringing another metal into contact with the one to be reduced. Zinc, zinc dust, aluminium powder, or aluminium filings are used as reducing agents. The electrolyte may be either lemon juice, dilute NaCl solution or dilute H_2SO_4 . (RATHGEN objects strongly to use the HCl proposed by RHOU SOPULOS). In every case, the antiquity must be washed for a long time with distilled H_2O before treating it chemically, and the same must be done thoroughly afterwards, in order to remove even the most minute traces of the chemicals. After drying the object is dipped preferably into Zapon lac; paraffin is less good, and wax is decidedly injurious.

RATHGEN reports in the „Chem.-Ztg.“ 1903, 897 on the preservation of silver coins and small iron objects (of which the interior is still sound) by fusing potassium cyanide (a mixture of KCN and NaCN or of KCN and K_2CO_3 may also be used) in a crucible and bringing the coin into the molten mass. The reduction is complete in a few minutes. The coin is then taken out with a pair of pincers boiled a few times in distilled H_2O to remove the KCN, washed with alcohol, dried, and brushed with a moderately hard brush. It is hardly necessary to varnish silver objects, but other things are to be coated with „zapon“ varnish. Iron objects may be dipped directly into melted paraffin which removes the water, or, having previously been dried, they may be coated with „zapon“ lac.

For larger objects KCN may be replaced by potassium sulphocyanide. Lead medals are treated by RATHGEN (Chem.-Ztg. 1903, 825) with zinc dust and sodium hydroxide, and after the reduction, are carefully washed several times in warm distilled water and dipped, while still wet, into molten paraffin, which has been heated to 120° in a tall vessel.

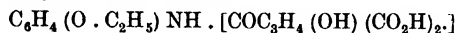
This vessel is necessary because the liquid froths and boils up so violently. When no more bubbles of steam rise from the medal the paraffin is allowed to cool down to about $70^\circ C$, and the medal is taken out, the excess of paraffin being removed with a soft cloth. The medal may be then put into the collection, but it is advisable that it should never be touched except with gloved hands.

The preservation of Babylonian clay tablets is described by RATHGEN in the Chem.-Ztg. 1903, 811, while RHOU SOPULOS (Chem. Zeitschr. 1903, 763) treats of the preservation of coloured clay objects; for fuller information we must, however, refer the reader to these works.

The above-mentioned use of zapon (see CELLULOID LAC) for preserving antiquities is treated in a detailed manner by RATHGEN in „Prometheus“ 1904 485 and 499. Especially carefully prepared lac is used, archive zapon lac for paper, and zapon varnish for metals. These are solutions of nitro-cellulose in amylacetate with the addition of a small amount of camphor. The archive zapon lac contains also a small amount of oil so as to render the remaining zapon film more flexible.

Antiseptics see DISINFECTION.

Apolysin. Monophenetidine citrate.



This preparation, Germ. Pat. 87428 is prepared from p. phenetidine and citric acid.

It is used medicinally as an internal remedy for neuralgic troubles, especially for migraine and the nervous ailments attendant on and following influenza.

Apomorphine $\text{C}_{17}\text{H}_{17}\text{NO}_2$. It is prepared from morphine $\text{C}_{17}\text{H}_{19}\text{NO}_2$ by treating it to 150° with HCl . It is colourless, soluble with difficulty in water, but readily in alcohol, ether and CHCl_3 . The hydrochloride $\text{C}_{17}\text{H}_{17}\text{NO}_2 \cdot \text{HCl}$ forms crystals readily soluble in water and alcohol.

It possesses powerful emetic properties particularly when injected subcutaneously. It is used medicinally as an emetic.

Apple oil. Fruit essence with a smell of apples. It is the amyl ester of valeric acid and is used in confectionery and to some extent for catching night-moths.

Apricot Ether see FRUIT ETHERS.

Aqua Distillata see WATER.

Aqua Fluoroformii see FLUOROFORM.

Araeometer. The scale of the Baumé araeometer for fluids lighter than water is so arranged that the point at which the spindle sinks in a solution of 1 pt. of common salt in 9 pts. H_2O is marked zero and the point at which it comes to rest in pure H_2O is termed 10. From the marks so fixed the degrees are measured in both directions. The Baumé araeometers for fluids heavier than water mark zero when dipped into pure H_2O and 10° when dipped into a 10% solution of NaCl at 17.5° . In the rational Baumé araeometer now almost universally in use the relation between Baumé degrees n and the density

of the fluid d is expressed by the formula $d = \frac{144.3}{144.3 - n}$.

A table of TWADDELL'S degrees, the araeometer degrees mostly used in England will be found converted into Baumé degrees in the appendix.

Argentamine = ETHYLENE DIAMINE SILVER NITRATE, LIQUOR ARGENTAMINI contains 10 pts. Ethylene diamine and 10 pts. AgNO_3 in 100 pts. H_2O .

It is a much used and well-known substitute for lunar caustic. Is especially applicable for gonorrhoea; also in cases of inflammation of the eyes, catarrh of the bowels &c.

Argentan, German silver, see NICKEL ALLOYS.

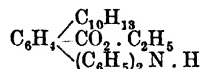
Argentum see SILVER.

Argentum nitricum = Nitrate of silver, see LUNAR CAUSTIC.

Argentum sulphuricum = Sulphate of silver, see SILVER COMPOUNDS No 4.

Argonin. A preparation of casein silver obtained by precipitating a neutral alkaline solution of casein with AgNO_3 and alcohol. It is a white powder, easily dissolved by warming in H_2O . Used as a specially soothing remedy in cases of gonorrhoea for which it is greatly valued.

Arhovin. Compound of diphenylamine and the ethyl ester of thymyl benzoic acid.



A liquid boiling at 218° , S. G. 1.055. Arhovin is an antiseptic, prescribed as an internal remedy in cases of chronic gonorrhoea. The most convenient form of administering it is in gelatine capsules containing 0.25 g of which 3—4 are to be taken daily. Arhovin is also used as a local disinfectant in the form of small sticks. As an injection a 2 % oily solution is used.

Aristol (DITHYMYLDIODE) $(\text{C}_6\text{H}_5\text{OI} \cdot \text{CH}_3 \cdot \text{C}_3\text{H}_7)_2$. Prepared according to Germ. Pat. 40739 by the action of a solution of potassium iodide on an aqueous solution of thymol in the presence of NaOH .

Pale brownish powder, insoluble in water, soluble with difficulty in alcohol, more so in fatty oils and readily in ether and CHCl_3 . Used instead of iodoform as a powder, as a salve or in ethereal solution.

It has been recommended for lupus and herpes, but is useful for wounds of every kind.

Aristo paper see PHOTOGRAPHIC PAPERS.

Aristoquin. The neutral carbonic acid ester of quinine $\text{CO}(\text{C}_{20}\text{H}_{23}\text{N}_2\text{O}_2)_2$. It forms a tasteless powder, without smell, melting point 189° , insoluble in H_2O . It is recommended as a perfectly tasteless substitute for quinine salts. It is said to be quite as effective without the harmful consequences of quinine.

Dose. For typhus and malaria 1 g once daily (or more). For colds and neuralgia 0.5 g daily once or oftener. Also valued as a remedy for whooping cough. Dose. 0.2—1.0 g daily given in small quantities at a time.

Arsenic. As. Atomic weight = 75.1. Arsenic is obtained by heating arsenical pyrites = $\text{Fe}(\text{SAs})_2$ in earthen pipes or jugs attached to receivers in which the sublimed arsenic condenses. It is purified by a second sublimation with powdered charcoal.

Arsenic forms bright steel-grey pointed rhombohedra. Also found native as a mineral, S. G. at 14° , 5. 727. It is brittle and can be powdered; it sublimes without melting. By sublimation in hydrogen the so called amorphous arsenic is obtained, Sp. Gr. 4.71. This again passes at 360° into the crystalline variety.

If arsenic vapour is quickly cooled the yellow modification of As results; this again changes very rapidly into black As. To obtain large quantities, the arsenic vapour is conducted into strongly cooled CS_2 . By cooling to -70° in the dark almost all the As separates as a yellow powder, this however on increase of temperature and exposure to light, again passes into the usual black modification.

Metallic arsenic is now used in large quantities only for shot making and to a certain extent for pyrotechnic purposes. It was formerly used in the manufacture of white copper (china silver) but this application is much lessened on account of the introduction of German silver and argentan.

Arsenic colours. 1. Realgar, red orpiment, ruby sulphur, disulphide of arsenic &c., As_2S_3 , are found in nature, in the form of ruby red crystals but

0.1—0.2 gramme is sufficient to kill an adult. It dissolves with difficulty in H_2O , easily in HCl , but is quite insoluble in alcohol. S. G. of crystals 3.69, of the amorphous form 3.74. At a temperature of 218° it sublimes without melting yielding a colourless odourless vapour.

True arsenious acid is not known in the free state but from a study of the arsenites its formula may be written H_3AsO_3 . White arsenic is much used for the manufacture of arsenic preparations, (e. g. Schweinfurt green), for preserving corpses, as a mordant in calico printing and for the treatment of the hair used for making hats. It is also used in glass melting &c. Large quantities were also used in aniline works for the reduction of nitro-benzene; but other substances are now used instead.

3. ARSENIC SULPHIDES.

a) ARSENIC DISULPHIDE Realgar, As_2S_2 . For occurrence, method of manufacture see ARSENIC COLOURS.

Realgar is used in the manufacture of fire works, for removing the hair from skins, in the making of shot and in colour printing as a reducing agent for indigo.

b) ARSENIC TRISULPHIDE Orpiment As_2S_3 . For occurrence and preparation see ARSENIC COLOURS.

Orpiment is used as a reducing agent for indigo, partly also for unhairing skins, it is the RHUSMA of the Orient.

c) ARSENIC PENTASULPHIDE As_2S_5 . This is obtained by fusing As and S, but also by the wet method of conducting heated H_2S for a long time into a solution of As_2O_3 containing an excess of HCl .

It is a light yellow powder, easily melted, which dissolves readily in alkalis and alkali sulphides. It of little use for technical purposes.

4. ARSENIC HYDRIDE (arseniuretted hydrogen) AsH_3 . A colourless gas with a strong unpleasant odour of garlic. Very poisonous. Because of the impurity of the materials commonly used in preparation, hydrogen nearly always contains this gas which can be recognized by MARSH's test. The brown stain formed is easily soluble in a solution of $NaClO$, while the corresponding antimony stain is insoluble.

Arsenic glass. By this is understood various combinations of arsenic, for instance white arsenic = arsenic acids, (see ARSENIC COMPOUNDS); grey arsenic = metallic arsenic, (see as above); red arsenic = orpiments, (see ARSENIC COLOURS).

Artificial Butter see MARGARINE.

Artificial Honey see HONEY.

Artificial Horn see HORN.

Artificial Indigo see INDIGO.

Artificial Leather see LEATHER SUBSTITUTES.

Artificial Manures see MANURES, ARTIFICIAL.

Artificial Perfumes see PERFUMES, ARTIFICIAL.

Artificial Silk see SILK, ARTIFICIAL.

Artificial Stone see GRANULAR LIME STONE AND STONE, ARTIFICIAL.

Artificial Sugars see SUGARS. ARTIFICIAL.

Artificial Wax see WAX.

Artificial Wood see XYLOLITH.

Artificial Wool see SHODDY and WOOL.

Artificial Yeast see YEAST.

Asaprol. Calcium salt of β -naphtholsulphonic acid. In order to prepare it β -naphthol is heated with conc. H_2SO_4 , the solution diluted with water, neu-

for technical purposes are mostly prepared artificially. It is obtained at the arsenic works by distilling arsenical pyrites with common iron pyrites.

The product obtained is then melted with either S or As according to the depth of colour desired.

As pigment it is little used on account of its highly poisonous character.

2. ORPIMENT POWDER. Trisulphide of arsenic, Chinese yellow, Persian and Spanish yellow, royal yellow, As_2S_3 . This combination occurs in nature in a coarse condition and also in gold-coloured flexible leaves. It is artificially made either by fusing together arsenic or realgar and sulphur, or by a wet process viz. conducting H_2S into an acid solution of As_2O_3 .

For the same reason as in the case of red arsenic, this is little used as a colouring matter except as Royal yellow for oil painting.

3. SCHWEINFURT GREEN see COPPER COLOURS.

Arsen ferratose see FERRATOSE.

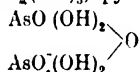
Arsenic Compounds.

1. ARSENIC TRICHLORIDE, As_2Cl_6 is usually obtained by adding a dilute solution of NaCl to a heated mixture of As_2O_3 and H_2SO_4 subsequently distilling and collecting the distillate in a well cooled receiver.

It is a colourless, fuming, thick fluid which is very poisonous. The As_2Cl_6 freed from excess of Cl solidifies at -18° , B. P. 134° ; S. G. (at 0°) 2.205.

2. ARSENIC OXIDES (arsenious acid anhydride, white arsenic &c.).

a) ARSENIC ACID H_3AsO_4 obtained commercially by boiling As_2O_3 with strong HNO_3 and evaporating the solution to dryness. It forms transparent rhombic crystals containing water of crystallization ($2H_3AsO_4 + H_2O$) which dissolve in moist air. Arsenic acid dissolves slowly but easily in H_2O giving a solution with an acid metallic taste. It is less poisonous than As_2O_3 . By heating to different temperatures three different arsenic acids can be obtained, namely ortho-arsenic acid $AsO_2^+(OH)_2$, pyro-arsenic acid



and meta-arsenic acid, $HAsO_3$. Salts can be produced from each of these three acids.

Arsenic is usually sold in the form of a thick syrupy fluid, though sometimes it is also sold in a dry state. Nowadays it is little used except for colour printing whereas it was formerly used in immense quantities in the manufacture of fuchsine.

b) ARSENIC PENTOXIDE, arsenic acid anhydride (As_2O_5)₂ is only important as the substance from which arsenic acid is obtained by heating. It forms a white mass with a S. G. of 3.734 which deliquesces in moist air, passing over into arsenic acid by absorption of atmospheric moisture.

c) ARSENIC SESQUIOXIDE As_2O_3 is seldom obtained from arsenic ore. It is mostly obtained from the flue-dust of furnaces in which arsenical ores have been roasted. From this dust, which already partly consists of As_2O_3 , the arsenious acid is obtained by sublimation. It can also be obtained from all kinds of arsenic ores by roasting in a reverberatory furnaces.

According to Eng. Pat. 14409 (1905) arsenic ores are heated in muffle-furnaces to a temperature not exceeding 750° , the resulting vapour is led away, oxidized by air and the As_2O_3 subsequently purified.

If quickly cooled it crystallizes into a glassy mass, arsenic glass. According to the Germ. Pat. 159541, glassy As_2O_3 is obtained by pressing the powder into a solid form.

Arsenious acid anhydride is usually termed simply arsenious acid. It forms a white colourless mass, without smell and of a sweetish flavour. Of this

0.1—0.2 gramme is sufficient to kill an adult. It dissolves with difficulty in H_2O , easily in HCl , but is quite insoluble in alcohol. S. G. of crystals 3.69, of the amorphous form 3.74. At a temperature of 218° it sublimes without melting yielding a colourless odourless vapour.

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tralized with excess of CaCO_3 , filtered, and the filtrate evaporated to dryness. A white or faintly red powder soluble in water. It has an antiseptic action and is administered internally for gout, rheumatism and typhus.

Asbestos. A natural magnesium silicate mixed with varying amounts of lime. Mineralogists distinguish the kinds of minerals belonging to this category viz. real asbestos (Tremolite, Amphibole asbestos, Chrysotile asbestos, Hornblende asbestos) and the amianth variety (serpentine asbestos, actinolite, Spanish chalk &c.) S. G. 2.5 to 2.9. Unattacked by acids and weak alkalis. For this reason and because it is incombustible, it is used for many purposes. The long flexible fibres, for instance, are used for fire-proof fabrics, cardboard &c.

It is made, (according to Germ. Pat. 144162) into a plastic mass by first grinding the asbestos with $\text{Al}_2(\text{SO}_4)_3$ and mixing with a solution of agar-agar. This mass adheres well to the materials to be covered, dries quickly and does not tear, while the addition of the Al salts renders it more proof against fire. The mass can be made more elastic by the addition of resin oil, or glycerine.

The Germ. Pat. 148936 treats of the production of asbestos articles by compressing finely-divided asbestos without the addition of any adhesive. The asbestos is heated to a temperature below the fusing point. Improvements on this process are protected by Germ. Pat. 156794 and 160981.

According to the former of these two patents the asbestos cardboard is first treated with 25 % H_2SO_4 , then dried and afterwards treated as in the Patent No. 148936. The second improvement is the impregnation of the finished objects with a boiling solution of water glass. The impregnation of the material with silicic acid renders it acid proof.

A new covering material is asbestos cement tiles or slates. These consist of cement in which asbestos fibres are imbedded.

Asbestos and Asbestos preparations:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Aseptol. o-phenol sulphonic acid $\text{C}_6\text{H}_4(\text{OH})\text{SO}_3\text{H}$. In the form of a 33 % solution it is used as an antiseptic.

Ashes.

In the case of the substances marked † the ash content is the pure ash content; for those marked * it is the crude ash content; the other numbers represent the content of the air dried substance. The elements present in the crude ash are: — C, H, O, N, P, S, Cl, Si, K, Na, Ca, Mg and Fe.

Ash content of certain animal and vegetable substances.

1000 parts contain	Parts of ash	1000 parts contain	parts of ash
Barley meal	23.3	*Deal	3.8
Barley (winter)	19.9	Egg white	46.1
Beechwood	4.9	Egg yolk	29.1
†Beef	12.6	Fruits:	
Beer (German)	62.4	Apples	14.4
Birchwood	6.4	Cherries	22.0
Blood (human)	8.0	Pears	10.7
Blood (oxen's)	35.5	Plums	18.2
†Bone charcoal	840.0	Grape (must)	15.4
†Bones (ground)	635.0	Grape (skins, pulp &c.)	39.8
Bran (wheat)	61.9	†Grass (young)	20.7
Cheese (ripe)	122.6	†Guano (Peru)	338.0
Coffee (beans)	31.9	Hay (meadow)	60.2

1000 parts contain	Parts of ash	1000 parts contain	Parts of ash
†Horn (ground).....	250.0	Rice (husked).....	3.9
Maize.....	15.1	Rye (meal).....	19.7
Milk (cow's).....	48.8	Rye (winter).....	19.7
Molasses charcoal.....	573.9	Sugar (cane).....	10.0
Molasses residues.....	150.6	Sugar beet.....	38.6
Molasses (sugar beet).....	99.7	Sugar beet juice.....	37.0
Oak (air dried).....	5.0	Superphosphates.....	630 to 880
*Oatmeal.....	28.4	Tea (leaves).....	54.8
Oats (whole).....	31.4	Tobacco (leaves).....	184.1
†Phosphates.....	915.0	Wheat (winter).....	20.9
†Phosphorite (Hannover).....	945.0	Wheat flour.....	4.7
Potatoes (peeled).....	37.7	Wine.....	2.1
Potatoes (peel).....	67.8	Wine lees.....	113.9
†Pork.....	10.4	Wool (unwashed).....	116.2
Pure wood (air dried).....	2.6	Wool (washed).....	11.1
Rape cake.....	64.2	†Veal.....	12.0
†Rape seed.....	39.1		

Ashes are used for different purposes. Woodashes, for example, are employed for the preparation of potash, and also in dyeing, bleaching and soap manufacture.

Bone ash serves for the preparation of phosphorus and phosphoric acid. From the ashes of seaweed iodine is obtained.

Wood-ashes and bone ash are used in the manufacture of cupels and the former is also used in the glass and faience-industries.

Asparagine. $\text{CH}_2 \cdot \text{CO} \cdot (\text{NH}_2)_2 \cdot \text{CH} \cdot \text{COOH}$. The amide of amidosuccinic acid, $\text{CH}_2 \cdot \text{COOH} \cdot \text{NH}_2 \cdot \text{CH} \cdot \text{COOH}$, is found in many plant buds. It is prepared by extracting the plant with cold water, evaporating the extract to a thin syrup and allowing it to stand for some weeks. The asparagine separates in a crystalline form and can be purified by recrystallization from hot water. After purification with animal charcoal it forms large, hard rhombic crystals which have a disgusting taste. It is used in medicine.

Asphalt (MINERAL PITCH).

An amorphous mass, brittle when cold, brown to black in colour. It becomes tough on warming and melts at 100° . S. G. 1.1—1.2; Hardness 2. Smells of bitumen, easily inflammable and burns with a thick smoky flame. It does not dissolve in water and only to a small extent in alcohol and ether, but very readily in benzene and turpentine oil.

Pure asphalt is found in the island of Trinidad and in Syria. In Europe it is made from the mineral Asphalt stone, (compact bitumen, found in Hannover, Switzerland and in France) by boiling in H_2O and skimming off the resin which floats on the surface.

The best asphalt is that found in Trinidad. The next best is that from Syria. These kinds are used for making lack, varnish, cement and painters' colours, while that made from asphalt stone is not so suitable for these purposes. However the latter, is extensively used in building, for covering roofs and masonry and also for paving streets.

The sensitiveness of pure asphalt to light is an important factor. It is so great that on exposure to light it loses its solubility in essential oils. For this reason it is much used in photography and photographic processes. Asphalt, as mentioned above, is also used for painter's colours, but is not very fast to light and has been the cause of the ruin of many a picture.

Nearly allied to asphalt are Ozokerite (mineral wax, see OZOKERITE) and Bitumen which is also found in fine veins in limestone and marl as well as in coal (bituminite).

German Asphalt or Artificial Asphalt is coal-tar or brown-coal-tar boiled down to the requisite consistency. The refuse from the distillation of tar is generally called asphalt and is used in the same way for building purposes, for making varnish and also for making „briquettes“. The Californian asphalt industry is of quite considerable importance. This asphalt is produced by distilling crude oils S. G. 0.9859—0.9333 in the presence of air. All fractions volatile below 650° C are eliminated, leaving only the asphalt which is then cooled.

The process of the English Pat. 7343 of 1904 is as follows. Ground slags and melted asphalt are mixed with some binding substance (such as tar, resin oil &c.) then sand, gravel, or such like is added and the whole boiled, well stirred, and finally allowed to cool. It forms a good asphalt; the proportions commonly used are as follows. 80 % slag, 10 % asphalt and 10 % binding and filling substances.

According to the American Pat. 790932, the asphalt is rectified and then mixed with 20 % bitumen and 5 % lignite. This is also said to be a successful process. The Swedish Pat. 18412 (1903) gives bitumen and powdered limestone as the basis for asphalt. In this process Orinoco asphalt oil, powdered limestone and milk of lime are used.

Resin, tar and sulphur are also melted together to form asphalt. One method for instance is to melt colophony, to add sulphur and to heat to 250°. The resulting substance is very similar to Syrian asphalt and is used as a substitute in photography in the copying and etching processes. Germ. Pat. 143147 protects a method of producing asphalt by heating a mixture of 11 pts. tar and 2 of resin; 1 pt. of sulphur and 11 pts. of slaked lime are then added. This yields a brown resinous mass which is a good substitute for asphalt and is insoluble in water. After being cooled the requisite amount of sand is added.

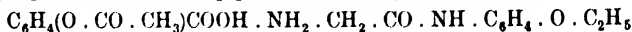
Asphalt breakers:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Asphalt Varnishes. Solutions of natural or artificial asphalt in benzene, tar oil, petroleum or for finer sorts, in oil of turpentine: in the latter case some kind of drying oil is added. Asphalt varnish is principally used for varnishing iron objects. If the coating be thin, the colour is brown, if thick it is a deep glossy black. Good sorts become very hard and insoluble in alcohol.

Aspirine see ACETYL SALICYLIC ACID.

Aspirophene, amidoaceto p-phenetidine acetylsalicylic acid



Probably not a true chemical compound but a mixture in molecular proportions of salicylic acid and mono acetyl phenocoll. M. P. 205°. A crystalline substance soluble in cold water and more readily in hot water. It is used as an anti-rheumatic and antineuralgic. Dose 1.0 gramme. Daily dose 5.0 to 8.0 grammes. (For children half the above doses).

Atmosphere. Technical measure of pressure. To render the given number comparable, a mean atmospheric pressure is taken as the basis of calculation, not the real pressure at a certain place and time.

Formerly the standard measure of atmospheric pressure was that at sea-level in latitude 45° reduced to 0°. This unit is called 1 old atmosphere

1 old Atm. = 760 mm Mercury column

1 old Atm. = 1.03333 kg per 1 sq cm.

Of late it has been decided to define atmospheric pressure as = 1 kg to 1 sq cm. (New Atmosphere)

1 New Atmosphere corresponds to 734.51 mm Mercury column

1 " " " " 1 kg per 1 sq cm.

Atmospheric air. A mixture of 23.2 % Oxygen, 75.5 % Nitrogen and 1.3 % Argon with carbonic acid and other gases. 1 liter of dry air in latitude 45° at 760 mm and 0° weighs 1.29306 g. Referred to water the S. G. under the above conditions is 0.0012934. At a given temperature t and pressure b, the S. G. of the air D amounts to

$$D = \frac{0.0012934 \cdot b}{(1 + 0.03665 \cdot t) \cdot 760}$$

Density of Atmospheric air comp. with water at 4° for the temp. t and pressure b.

t	b = 720 mm	730 mm	740 mm	750 mm	760 mm	770 mm
0°	0.001225	0.001242	0.001259	0.001276	0.001293	0.001310
1°	0.001221	0.001238	0.001255	0.001272	0.001289	0.001306
2°	0.001216	0.001233	0.001250	0.001267	0.001284	0.001301
3°	0.001212	0.001229	0.001246	0.001262	0.001279	0.001296
4°	0.001208	0.001224	0.001241	0.001258	0.001275	0.001291
5°	0.001203	0.001220	0.001237	0.001253	0.001270	0.001287
6°	0.001199	0.001216	0.001232	0.001249	0.001266	0.001282
7°	0.001195	0.001211	0.001228	0.001244	0.001261	0.001278
8°	0.001190	0.001207	0.001223	0.001240	0.001257	0.001273
9°	0.001186	0.001203	0.001219	0.001236	0.001252	0.001269
10°	0.001182	0.001198	0.001215	0.001231	0.001248	0.001264
11°	0.001178	0.001194	0.001211	0.001227	0.001243	0.001260
12°	0.001174	0.001190	0.001206	0.001223	0.001239	0.001255
13°	0.001170	0.001186	0.001202	0.001218	0.001235	0.001251
14°	0.001165	0.001182	0.001198	0.001214	0.001230	0.001246
15°	0.001161	0.001178	0.001194	0.001210	0.001226	0.001242
16°	0.001157	0.001174	0.001190	0.001206	0.001222	0.001238
17°	0.001153	0.001169	0.001185	0.001201	0.001218	0.001234
18°	0.001149	0.001165	0.001181	0.001197	0.001213	0.001229
19°	0.001146	0.001161	0.001177	0.001193	0.001209	0.001225
20°	0.001142	0.001157	0.001173	0.001189	0.001205	0.001221
21°	0.001138	0.001154	0.001169	0.001185	0.001201	0.001217
22°	0.001134	0.001150	0.001165	0.001181	0.001197	0.001213
23°	0.001130	0.001146	0.001161	0.001177	0.001193	0.001209
24°	0.001126	0.001142	0.001158	0.001173	0.001189	0.001204
25°	0.001122	0.001138	0.001154	0.001169	0.001185	0.001200
26°	0.001119	0.001134	0.001150	0.001165	0.001181	0.001196
27°	0.001115	0.001130	0.001146	0.001161	0.001177	0.001192
28°	0.001111	0.001127	0.001142	0.001158	0.001173	0.001188
29°	0.001108	0.001123	0.001138	0.001154	0.001169	0.001184
30°	0.001104	0.001119	0.001135	0.001150	0.001165	0.001181

Atomic weights. For tables see appendix. For estimation see **MOLECULAR WEIGHTS.**

Atoxyl. Meta arsenic acid anilide $C_6H_5NO_2As$. A white powder soluble in 5 pts. of water. Contains 37 % As_2O_5 . It is used as a subcutaneous injection and according to R. KOCH it is a specific remedy for sleeping sickness.

Atropine (Daturine). An alkaloid found in the deadly night shade (*Atropa Belladonna*), in *Datura Stramonium* and in henbane (*Hyoscyamus niger* &c.). It is manufactured commercially from the belladonna root.

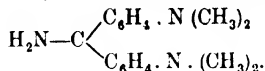
Pure Atropine $C_{17}H_{23}NO_3$ forms heavy crystalline needles M. P. 115.5°. It is without smell and of a bitter taste. It dissolves with difficulty in cold, more readily in hot water, but quite easily in alcohol, chloroform, amyl alcohol and toluene. In ether it is less soluble and almost insoluble in petroleum ether. It is an extremely violent poison. It is used medicinally in the form of soluble salts as a narcotic and to prevent night sweats of consumptives. It is also used as an injection in cases of cramp and neuralgia. Also a 0.5 % solution is used as an outward application, dropped into the eye to enlarge the pupil, maximal dose 0.001 g. Max. dose per diem 0.003 g.

Aubépine see ANISALDEHYDE.

Auramine. A coal-tar dyestuff belonging to the diphenylmethane group. The simplest form of this group, not a dye, is Diamidodiphenylmethane, $H_2N-C_6H_4-CH_2-C_6H_4-NH_2$. An important substance for the production of auramine is benzophenone $C_6H_5-CO-C_6H_5$ (see also KETONES) and its

derivative Tetramethyldiamidobenzophenone $CO \begin{matrix} \swarrow C_6H_4 \cdot N \cdot (CH_3)_2 \\ \searrow C_6H_4 \cdot N \cdot (CH_3)_2 \end{matrix}$ By

substituting an amide group for the carbonyl group the simplest auramine is obtained Amidotetramethyldiamidodiphenylmethane



Auramine can be prepared by fusing tetramethyldiamidobenzophenone with ammonium chloride or by melting tetramethyldiamidodiphenylmethane with sulphur and at the same time passing ammonia through the melt.

Auri pigmentum see ARSENIC COLOURS.

Aurum colloidal see COLLAURIN.

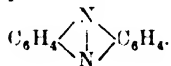
Autoclaves (Digestors):

Friedrich Hoeckmann, Berlin SO. 16, Brückenstr. 6b (see advt.).

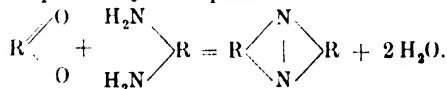
Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

W. Stann, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Azine dyes. A class of dyes in which the group $\begin{matrix} \diagup N \diagdown \\ | \\ N \end{matrix}$ must be considered as the chromophore. The simplest of the azines is Phenazine



The azines are formed by the action of orthodiamines on orthoquinones when both oxygen atoms of the quinone unite with the amide-hydrogen to form H_2O . The reaction is expressed by the equation



The following dyes, corresponding to the above constitutional formula, are now generally classed among the azine dyes: EURHODINE, SAFRANINE (and APOSAFRANINE) INDULINE as well as the quinoxaline dye known as FLAVINDULINE.

The Eurhodines are formed by the action of o-amidoazo-bodies on monamines e. g. Eurhodine itself formed by heating o-amidoazotoluene with α -naphthyl-

mine hydrochloride. Similar to the Eurhodines are the Eurhodoles (Oxyazines) which are obtained by heating the eurhodines with conc. HCl to 180°.

With regard to the constitution and preparation of the SAFRANINES compare the special article SAFRANINES.

See also special article for INDULINES.

Azo-dyes. A very important class of coal-tar dyes in which the chromophore is the azo-group —N=N— (comp. AZO-COMPOUNDS) always combined with two benzene nuclei or other aromatic hydrocarbons. If only one azo-group is present the substance is called a monoazo-dye or simply an azo-dye while if several azo groups are present the substance are then diazo-, triazo- and tetrazo-dyes.

The range of the azo-dyes is simply boundless and we must confine ourselves to short references.

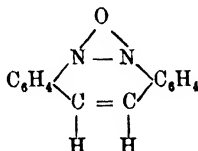
The most important groups of the monoazo-dyes are the AMIDOAZO-DYES and the OXYAZO-DYES. On introducing the azo-group into hydrocarbons coloured bodies are formed which have not the properties of dyestuffs. The action on the fibres is only brought about by the introduction of other groups, which give the azo-bodies acid or basic properties.

AMIDOAZOBENZENE $\text{C}_6\text{H}_5 \cdot \text{N} : \text{N} \cdot \text{C}_6\text{H}_4 \cdot \text{NH}_2$ is made from diazoamidobenzene. It is prepared by treating aniline with just so much HCl and NaNO_2 that only about $\frac{1}{3}$ is converted into diazoamidobenzene which remains dissolved in the excess of aniline. On being gently heated the diazoamidobenzene ($\text{C}_6\text{H}_5 \cdot \text{N} : \text{N} \cdot \text{NH} \cdot \text{C}_6\text{H}_5$) is converted into amidoazobenzene. The latter is itself not a dyestuff but its sulphonic acids, for instance, are.

OXYAZOBENZENE $\text{C}_6\text{H}_5 \cdot \text{N} : \text{N} \cdot \text{C}_6\text{H}_4 \cdot \text{OH}$ is obtained by the action of diazobenzene on sodium phenate. If the oxyazobenzene be treated with fuming sulphuric acid, the oxyazobenzene-p-sulphonic acid. $\text{HSO}_3 \cdot \text{N} : \text{N} \cdot \text{C}_6\text{H}_4 \cdot \text{OH}$ is formed which is a dyestuff, known commercially under the name of tropaeolin Y. It is the simplest oxyazo-dyestuff. With regard to disazo-dyes, trisazo-dyes and tetrazo-dyes see the special articles.

Azoxy-dyes. A class of coal tar dyes with the chromophore $\text{—}\overset{\text{O}}{\underset{\text{N}}{\text{N}}}\text{—}$

Azoxystilben may be regarded as the parent substance of these dyes; its formula is



The compounds belonging to this class are all substantive cotton dyes.

Azo-compounds. A class of organic compounds with the group —N=N— in which the free valencies are each bound to an aromatic hydrocarbon-rest. For the differences between these and the diazo-compounds see the article on DIAZO-COMPOUNDS. The azo-derivatives are formed by the reduction of the nitro-derivates $\text{C}_n\text{H}_{2n-7} \cdot \text{NO}_2$ with alcoholic KOH or with sodium amalgam and also by the oxidation of aniline and its homologues. The azo-compounds are bodies which crystallize in either yellow or red crystals, are insoluble in H_2O , can be converted by oxidation with CrO_3 or HNO_3 into azoxy-derivatives, by reduction with $(\text{NH}_4)\text{HS}$ into hydrazo-derivatives.

The following azo-compounds may be mentioned.

1. AZO-BENZENE $\text{C}_6\text{H}_5\text{—N=N—C}_6\text{H}_5$. Obtained by the reduction of nitrobenzene with sodium amalgam. Recently according to the Germ. Pat. 127727

and 141535 it has been prepared by the electrolysis of nitrobenzene at a high temperature and in an alkaline medium. The cathode (the vessel itself may be advantageously used as such) must be large and the anode as small as possible. Azo-benzene forms orange red monoclinic crystals Sp. Gr. 1.203 M. P. 68°, B. P. 293°.

2. **HYDRAZOBENZENE.** $C_6H_5-NH-NH-C_6H_5$. Obtained by the reduction of azobenzene with ammonium sulphide or with zinc dust, and more recently by the electrolysis of nitrobenzene. An improvement in this process is described in Germ. Pat. 181116. An electrolyte such as benzene, toluene or xylene is employed as a solvent for the hydrazobenzene. Colourless plates with a smell resembling camphor M. P. 131°. Converted by HCl or H_2SO_4 into the isomeric benzidine.

3. **AMIDOAZOBENZENE** $C_6H_4(NH_2)-N=N-C_6H_5$. Of the three isomers the p-amidoazobenzene is especially important. It is technically prepared from diazoamidobenzene $C_6H_5-N=N-NH(C_6H_5)$ and aniline salts at low temperatures. It forms yellow rhombic needles M. P. 123°. Weak monacid base, the salts of which are used as dyes.

4. **AZOTOLUENE** $C_6H_4(CH_3)-N=N-C_6H_4(CH_3)$. The three isomerides are formed by treating the corresponding nitrotoluenes with sodium amalgam or zinc dust. p-azotoluene is usually prepared by treating p-toluidine with chloroform and bleaching powder; Orange yellow needles M. P. 144°. More used than the other two isomers.

5. **AMIDOAZOTOLUENES** $C_6H_4(CH_3)-N=N-C_6H_3(CH_3) \cdot NH_2$. The o-amidoazotoluene is important, and can be obtained by passing nitrous acid into o-toluidine and afterwards boiling with dilute HCl. It forms small plates which glisten like gold. M. P. 100°.

Azure Blue see COBALT COLOURS.

B.

Babbit metal see ANTIFRICTION METALS.

Bacillol (LIQUOR CRESOLI SAPONATUS). Cresol soap solution.

It is a brown oily liquid which smells of tar, and is obtained by heating cresol with a potash-soap solution. It gives a clear solution in H_2O , and is used on a large scale as a disinfectant.

Bacteriology Apparatus.

Carl Zeiss, Jena. Mikro Catalogue M 184, P. 102—3. Prospekta Mikro 228, 230 and 231.

Baking powder (YEAST POWDER). Different mixtures have been brought into commerce as a substitute for yeast. The evolution of gas (CO_2) causes the dough to rise.

For fine pastry ammonium carbonate, or a mixture of sodium bicarbonate and tartaric acid or cream of tartar (Cremor tartari) is used as baking powder.

Very often sodium bicarbonate and hydrochloric acid are used for bread making. In this case the acid is added to the water used in making the dough, while the sodium bicarbonate is only mixed in at the last. Instead of HCl, very often calcium biphosphate or a mixture of this with KCl is used. Other mixtures, although of known composition, are trade secrets as far as their method of preparation is concerned. A common recipe for cakemaking is a mixture of 1 pt. sodium bicarbonate, 2 pts. cream of tartar, and 10—20 pts. of flour or milk sugar. An addition of starch is said to be very favourable. Thus a baking powder having the following composition is recommended:—35 pts. sodium bicarbonate, 25 pts. cream of tartar, and 40 pts. of potato starch. Usually 15—20 grms baking powder are taken to $\frac{1}{2}$ kg meal.

Another recipe is as follows:— 15 pts. tartaric acid, 20 pts. sodium bicarbonate, and 35 pts. rice starch; 30—40 grms of the powder to be mixed with 500 grm flour.

The prices of baking powders vary very much according to their origin and composition. "Self-raising flour", i. e. flour with which the necessary amount of baking powder is already mixed, is sold. A well known make of self-raising flour consists of 84 grms. sodium bicarbonate, 188 grms cream of tartar, and 10 kg wheat flour.

Balances.

Analysis balances:

A. Verbeek & Peckholdt, Dresden, Germany.

Automatic Balances:

Benno Schilde, Hersfeld (Hessen-Nassau), Germany.

Balata. The dried latex of certain trees, more particularly of *Mimusops balata* (*Sapota Muelleri*) of Guiana and Venezuela. In order to prepare it the tree is felled or incisions are made in the bark. The latex exudes as a whitish or some times reddish spongy mass.

Crude balata comes into the market in the form of thin plates, generally mixed with bits of bark. It is reddish-white to brown in colour, leathery, flexible and more elastic than the closely allied guttapercha. It is a worse conductor of heat and electricity than the latter, and is soluble in the same solvents. S. G. 1.044. It becomes plastic at 50° M. P. 149°. It is used for belts, boot soles, saddle flaps, in dentistry and as an insulator for electrical purposes.

Ballistite see GUNPOWDER.

Balls.

Cast-steel-balls:

Kugelfabrik Fischer A.-G., Schweinfurt, Germany.

Ball- and roll-bearings:

Kugelfabrik Fischer A.-G., Schweinfurt, Germany.

Ball-mills:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Ball races:

Kugelfabrik Fischer A.-G., Schweinfurt, Germany.

Balsams. By the name balsam is understood a mixture of resinous substances formed and stored up by various plants. Some of them flow out on their own accord, and some are only exuded after the bark has been injured.

Among the balsams the following deserve notice: Resins or Gums, gum resins, and fossil gums.

1. **ACAJOUBALSAM (CARDOL).** Obtained from the stone fruits of *Anacardium occidentale* (mahogany nuts) by extracting the chopped-up fruits with ether-alcohol, and removing the tannic acid by washing with water. The most important constituent of acajoubalsam is the Cardol; the balsam itself is termed crude cardol (*CARDOLUM VESICANS*). It is used in medicine as a blistering agent; it is also used for the manufacture of indelible inks and for inks for rubber stamps.

A similar balsam is also obtained from the fruit of *Anacardium orientale*, also termed crude cardol. It is known as *CARDOLUM PEURIENS*.

2. **CANADA BALSAM (BALSAMUM CANADENSE).** A balsam obtained from *Abies balsamica* (balsam fir). It is obtained by making in the spring a horizontal cut in the bark, near the ground, and catching the balsam in vessels.

It is purified by filtration. A perfectly clear and transparent balsam, at first almost colourless, afterwards becoming pale yellow, of about the consistency of honey, and finally solidifying without becoming milky. Sp. Gr. (at 15°) 0.985—0.999. Refractive index 1.528. Completely soluble in ether, benzene, chloroform, and carbon disulphide. It is used for cementing lenses together, for optical apparatus, for mounting microscopic preparations, &c.

3. COPAIVA BALSAM. Is obtained like that from firs (see above CANADA BALSAM), from several South American trees which belong to the species *Copaifera*.

Copaiva balsam is a clear syrupy, yellowish or pale brownish liquid of a spicy smell and bitter pungent taste; it gradually solidifies to an odourless resin. Sp. Gr. 0.935—0.998. The following kinds are recognized, Brazilian copaiva balsam, Para copaiva balsam, and West Indian copaiva balsam.

Copaiva balsam is a valued medicinal remedy, and is also used for the preparation of lacs and varnishes and for making transparent paper (tracing paper) &c. Germ. Pat. 167 170 protects a process for the manufacture of neutral preparations of copaiva balsam. Germ. Pat. 183185 describes the preparation of solid condensation products of this balsam.

4. PERU BALSAM (BALSAMUM PERUVIANUM). Under this name are included various resinous and oily aromatic substances, of which the San Salvador balsam is most frequently used. It is obtained from the tree *Myroxylon Pereirae* by making an incision in the stem after the bark has been partially separated.

Peru balsam is a dark brown syrupy, resinous-oily liquid of a spicy and pungently bitter taste, with a pleasant smell resembling vanilla. Sp. Gr. 1.135—1.150. It contains no volatile oil and does not solidify in the air; it has however a large proportion of cinnamic acid, cinnamic-benzylester and other aromatic compounds.

Peru balsam is used medicinally, in perfumery and as a substitute for vanilla in chocolate manufacture.

5. STORAX (STYRAX). A balsam resembling turpentine, obtained from the bark of the storax tree, *Liquidambar orientale* (a native of Syria and Asia Minor) by extraction with water and pressing.

The liquid storax thus obtained is a very tough brown mass, which gradually dries up but always remains sticky. It is purified by heating on a water-bath, dissolving in alcohol, and then filtering and evaporating the solution. It is used in medicine, and particularly in perfumery. It is characterised by a high percentage of cinnamic-esters, free cinnamic acid, benzoic acid, volatile oils, styrol, and styracine.

The so-called solid or red Storax (STYRAX CALAMITA) is an artificial product obtained by mixing storax of inferior value with saw-dust, and pressing the mixture. It is a brownish red, brittle mass, which forms the material for fumigating-candles and fumigating powder.

6. TURPENTINE (TEREBINTHINA) see special article.

7. TOLU BALSAM (BALSAMUM TOLUTANUM) obtained from the South American *Toluijera balsamum*. The gum exuded after the stem has been tapped is at first brownish yellow and liquid. It often comes into commerce as a brown-red, brittle crystalline mass. It possesses a more aromatic odour than Peru balsam, and has a sweet taste; it is otherwise closely related to the latter.

It is used in medicine, but more largely in perfumery.

Bandages.

1. WADDING (COTTON). For the preparation of wadding for bandages raw cotton with as long a fibre as possible is used. First it is treated with a weak boiling solution of Na_2CO_3 to remove the fat, then pressed, bleached

with hypochlorite solution, pressed again, washed with pure water, then with very weak hydrochloric acid, and finally with pure H_2O again until perfectly neutral.

2. ANTISEPTIC GAUZE. Smooth, light, loose cotton texture, which contains on 1 sq. cm 11 \times 11 to 15 \times 15 fibres. 1 sq. met. weighs 30—45 grm. The raw stuff — a white light and undressed muslin — is washed with hot water, then laid in cold water for 24 hours, pressed, bleached with weak hypochlorite solution, afterwards washed first in pure H_2O , then in very weak HCl, and finally in pure H_2O , and dried.

3. IMPREGNATED DRESSING MATERIALS. Wadding or muslin so impregnated that certain definite weights of the dressing are steeped in a solution of the reagent, which is applied in such quantity that it is completely absorbed at moderate pressure. The stuffs are dried at ordinary temperature or at the highest at 25—30°C., in dust-free airy chambers which are protected from bright daylight, then immediately packed.

4. PEAT DUST. The peat of the high moors is superficially dried, then broken up, and afterwards dried again, and then torn in machines in fibres as long as the finger. In this way peat litter is obtained which finds commercial employment. By means of sieves the powder also formed is separated from the fibres; this powder, called peat dust, with 2 % H_2SO_4 acts as a very strong disinfectant, and is used as a dressing material.

5. STERILISED BANDAGES. Usually the bandages or dressings are sterilised by dry heat, and then packed. This process is however not free from objections; the only certain method is the sterilisation with steam, in such a way that the steam acts on the already packed goods.

Barberry. The juice of this plant is used in the manufacture of the finest kinds of leather.

Barium. Ba. At. Wt 137.4. Sp. Gr. 3.75. Melts at a higher temperature than cast iron. It oxidizes in the air very quickly, decomposes H_2O very energetically, and burns with a bright light on being heated. Metallic Ba, which is yellow like brass, is obtained by the electrolysis of fused $BaCl_2$ in the presence of NH_4Cl . On adding sodium amalgam to a heated saturated aqueous solution of $BaCl_2$ a solid crystalline silver-coloured barium amalgam is obtained. By heating the latter in a stream of H metallic Ba may also be obtained, but is impure (containing Hg).

According to a lecture given by GUNTZ (of Nancy) at the International Congress for Applied Chemistry in Berlin 1903, pure barium is obtained by first making a 3 % barium amalgam by electrolysis of $BaCl_2$ with a Hg cathode, concentrating this by pressure to a 60 % amalgam, and then carefully distilling *in vacuo* at 900°. The Ba thus obtained is said to be quite pure, and melts at 850°. According to later communications from GUNTZ good yields are obtained by this method. The Ba obtained is glistening, soft as Pb, and turns from gray to black in the air. B. P. *in vacuo* 1150°.

Although the compounds of Ba are so important technically, the metal itself finds no use practically.

Barium colours.

I. BARIUM WHITE (PERMANENT WHITE; MINERAL WHITE; NEW WHITE; SNOW WHITE; BLANC FIXE) $BaSO_4$. Not only is the naturally occurring heavy spar, in a finely ground state, used as a paint, but also the artificially prepared (precipitated) barium sulphate which is known under the names given above. The raw material for the manufacture is partly heavy spar and partly witherite. The heavy spar is finely ground and reduced by heating with C to BaS. This was formerly converted into $BaCl_2$ by means of HCl and then the permanent white precipitated from the aqueous solution of this salt by means of cold

dilute H_2SO_4 or a sulphate solution. Of recent years the preference has been given to a method in which the BaS is simply dissolved in H_2O and the BaSO_4 precipitated from this solution by means of Na_2SO_4 .

According to the Amer. Pat. 737740 artificial BaSO_4 is prepared from the natural heavy spar by strongly heating the latter with C by which means BaO , BaS and SO_2 are formed. By treating the mixture of $\text{BaO} + \text{BaS}$ with H_2O , barium hydroxide $\text{Ba}(\text{OH})_2$ is formed which is converted by means of Na_2SO_4 into BaSO_4 while at the same time NaOH is obtained. The Na_2SO_4 is prepared from NaCl by means of SO_2 in the presence of H_2O and O .

The manufacture of permanent white from witherite (BaCO_3) is still more simple. By treating the carbonate with HCl the chloride is obtained and this is treated as described above.

Permanent white is the most stable of all paints and so is becoming more used, thus displacing white lead. It usually comes into commerce in the form of a tough dough.

With regard to the barium paints which contain Zn see the article **ZINC COLOURS**.

According to the English Pat. 22567 (1903) a paint is obtained, which consists of BaCO_3 and $\text{Al}_2(\text{OH})_6$, by precipitating the solutions of Ba and Al salts with the carbonates of the alkali metals.

2. BARIUM YELLOW see under CHROMIUM COLOURS.

Barium compounds. The following Ba compounds are commercially important.

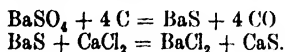
1. **BARYTA** see 13 **BARIUM OXIDE**.
2. **BARIUM ACETATE** $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2$. Obtained by neutralizing BaS or BaCO_3 with acetic acid. It forms easily soluble crystals. It is used in dyeing and calico printing for the preparation of red mordant (see **ALUMINIUM MORDANTS**) and for this purpose is decomposed with alum or aluminium sulphate.
3. **BARIUM BORATE** $\text{Ba}(\text{BO}_2)_2$. Obtained by precipitating baryta water with boric acid or (usually) by decomposing BaCl_2 with borax.
4. **BARIUM CHLORATE** $\text{Ba}(\text{ClO}_3)_2 + \text{H}_2\text{O}$. Is prepared according to the Germ. Pat. 89844 by the electrolysis of a mixture of BaCl_2 and BaCO_3 in aqueous solution or suspension. Vessels of lead or earthenware are used and a current density of 500—1500 Amp. per 1 sq. mm. is employed. The electrolysed lye is freed from the greater part of the BaCl_2 by evaporation while the chlorate and chloride are separated from the residue by means of fractional crystallization. The electrolysis probably takes place in such a way that the BaCl_2 is first decomposed with the formation of $\text{Ba}(\text{OH})_2$ and Cl . The products of decomposition then react with each other. The addition of BaCO_3 is only made to facilitate the process.

This electrochemical method of manufacturing the chlorate has almost displaced the old method in which potassium chlorate was decomposed with hydrofluosilicic acid and the resulting solution neutralized with BaCO_3 .

Barium chlorate forms monoclinic prisms, which give off their water of crystallization at 120° ; it dissolves in 3 pts. cold H_2O and 0.7 pts. hot H_2O . When quickly heated it explodes; this is also the case when it is mixed with combustible substances and then subjected to a blow.

It is used in fireworks for producing green fire.

5. **BARIUM CHLORIDE** $\text{BaCl}_2 + 2 \text{H}_2\text{O}$. It is prepared either from witherite BaCO_3 or from heavy spar BaSO_4 as has been already mentioned under **BARIUM WHITE**. If the production of the latter is not desired the BaCl_2 is prepared by heating heavy spar with coal, lime stone and calcium chloride in a furnace in which the reaction takes place in two phases:—



The fused mass is lixiviated with H_2O by passing in steam, and is then evaporated. According to the English Pat. 8184 (1902) $BaCl_2$ is prepared with the help of iron chloride by mixing solutions of Fe_2Cl_6 and BaS , or by fusing Fe_2Cl_6 with heavy spar and charcoal, and extracting the $BaCl_2$ with H_2O . The iron sulphide formed at the same time can be roasted.

$BaCl_2$ may also be obtained, according to Germ. Pat. 162913, by allowing gaseous Cl to react with heated BaS , whereby the mass begins to glow and combination takes place, $BaCl_2$ and barium polysulphides being formed. The latter can be easily converted into $BaCl_2$ and S if the further chlorination be carried out in aqueous solution by means of sulphur chloride.

According to Germ. Pat. 186738 $BaCl_2$ can be prepared by heating BaS and $MgCl_2$ in aqueous solution in autoclaves. The $MgCl_2$ is obtained from the residues of the potash industry and pure magnesia is obtained as a by-product.

$BaCl_2$ crystallizes in colourless rhombic plates. 100 pts. H_2O dissolve 33 pts. at 10° and 58 pts. $BaCl_2$ at 100° . On heating above 58° it loses H_2O without melting. The calcined salt melts between 750° and 850° .

Barium chloride is used for prevention of fur in boilers, for the manufacture of barium sulphate and in analytical chemistry. It also finds use in the earthenware industry for rendering insoluble the soluble sulphates occurring in many clays, which effloresce on drying.

6. BARIUM CARBONATE $BaCO_3$. Occurs naturally as witherite and is obtained artificially by treating BaS with gaseous CO_2 . In the latter process the S which is mixed with the product of reaction is removed by boiling with $Ba(OH)_2$ with which it combines and the purified $BaCO_3$ then filtered off.

It is insoluble in cold and in hot water as well as in alcohol, readily soluble in HCl . It is used for the manufacture of colourless crucibles and terra cotta, for fusible glasses and stone ware glazes.

With regard to the naturally occurring barium carbonate see article on WITHERITE.

7. BARIUM CHROMATE see CHROMIUM COLOURS.

8. BARIUM FLUORIDE BaF_2 . Obtained by the action of NaF on $Ba(NO_3)_2$, by neutralizing baryta water with HF or finally by digesting freshly precipitated $BaCO_3$ with excess of HF . White granular powder sparingly soluble in H_2O readily soluble in HNO_3 , in HCl , and in HF .

9. BARIUM MANGANATE $BaMnO_4$. According to the English Pat. 28585 (1903) it is obtained by the action of suitable Ba salts on alkali manganates. (It is not obvious what is capable of being patented in this process.) According to another process of the same patent air which has been freed from CO_2 is passed over a heated dry mixture of pulverised MnO_2 and $NaOH$. The $BaMnO_4$ is then precipitated by $Ba(OH)_2$ from the solution obtained by lixiviating the mass thus prepared. Barium permanganate is prepared in a similar way.

10. BARIUM NITRATE $Ba(NO_3)_2$. It is obtained either by dissolving witherite in dilute HNO_3 , evaporating the solution and purifying by recrystallisation, or from $BaCl_2$. The latter is dissolved in H_2O by passing in steam and the necessary amount of $NaNO_3$ is added, the whole being constantly stirred. The sparingly soluble $Ba(NO_3)_2$ is precipitated and is purified by recrystallization.

Barium nitrate forms colourless regular crystals which contain no water but are somewhat deliquescent. 100 pts. H_2O dissolve 7 pts. $Ba(NO_3)_2$ at 10° and 32 pts. at 100° ; it is more difficultly soluble in dilute HCl and HNO_3 . On being ignited it decomposes and BaO is left behind. It is chiefly used for the preparation of barium peroxide; it is further used for producing green fire in fireworks and for the manufacture of several blasting powders.

11. BARIUM NITRITE $Ba(NO_2)_2 + H_2O$. Prepared according to WITT and LUDWIG in the following manner: $BaCl_2$ and $NaNO_2$, in molecular proportions, are mixed together dry, and as a solvent for this mixture, a concentrated

solution of NaNO_2 is used (equal in amount to that of the dry mixture of salts). Double decomposition at once takes place and the resulting NaCl is precipitated as a coarse crystalline meal and is separated from the hot lye in a steam funnel. On cooling $\text{Ba}(\text{NO}_3)_2 + \text{H}_2\text{O}$ separates out of this solution in beautiful crystals. The mother liquor, from which the crystals are removed in a centrifugal machine, contains the excess of NaNO_2 . It is heated to boiling point and at once used for another portion of the salt mixture.

12. BARIUM OXALATE $\text{BaC}_2\text{O}_4 + \text{H}_2\text{O}$. Obtained by precipitating solutions of barium salts with oxalic acid.

13. BARIUM OXIDES.

a) BARIUM OXIDE BaO . Formerly only obtained by strongly igniting $\text{Ba}(\text{NO}_3)_2$ or $\text{Ba}(\text{OH})_2$; of late years however several other useful methods have been discovered.

Thus W. FELD has found that BaCO_3 , contrary to former assertions, is also decomposed on heating, yielding BaO , being similar in this respect to limestone. The main condition for the success of this operation is the use of combustibles free from H, that is materials from which the gases evolved contain no H_2O ; otherwise $\text{Ba}(\text{OH})_2$ is formed. The Germ. Pat. 149803 protects an arrangement of this patent in which the stuff to be heated is placed in capsules of oval cross section. BaCO_3 or BaSO_4 and charcoal or mixtures of C with BaSO_4 and an alkali sulphate may also be burnt.

FRANK (Germ. Pat. 135330) prepares BaO by reducing barium salts (e. g. BaCO_3) with barium carbide BaC_2 . For this purpose the materials are finely ground and well mixed, and then heated with exclusion of air.

In order to obtain porous BaO , BRADLEY and JACOBS (Germ. Pat. 142051 and 125936) heat barium hydroxide and barium carbide, mixed (in the proportion of their molecular weights) with hydrocarbons, to the melting point, until all the hydrocarbons have disappeared. The specially porous BaO thus obtained is eminently suitable for the manufacture of BaO_2 .

The United Barium Company of Niagara Falls manufactures BaO according to the Germ. Pat. 111667 by heating 4 mol. BaSO_4 (heavy spar) with 4 atoms of C (coke) in the electric furnace. SO_2 is liberated in this process.

Barium hydrate is also obtained.

BaO is also manufactured according to the Amer. Pat. 737740 (mentioned in article barium colours under No. 1).

According to the Germ. Pat. 158950 BaO may be prepared from BaCO_3 by heating the latter mixed with $\text{Ba}(\text{NO}_3)_2$ and a reducing agent (C) to a red heat whereby a reaction takes place according to the equation

$\text{BaCO}_3 + \text{Ba}(\text{NO}_3)_2 + 2\text{C} = 2\text{BaO} + 2\text{NO}_2 + 3\text{CO}$. The English Pat. 4217 (1904), which aims at an expansion of the same process, states that volatile hydrocarbons are to be added to the mixture in order to obtain the BaO in a porous state. The heating may be advantageously carried out in an electric furnace.

The English Pat. 21392 (1903) treats of a process which is almost similar to the one described above.

BaO forms either an amorphous colourless mass or small crystals; it unites with H_2O to form barium hydroxide.

b) BARIUM HYDROXIDE $\text{Ba}(\text{OH})_2$. As mentioned above it is formed (with great evolution of heat) by the action of H_2O on BaO . It is further formed by heating BaCO_3 (witherite) in a current of steam. It may also be obtained from BaS [prepared by heating BaSO_4 with reducing agents, (charcoal and tar)] in iron retorts. The BaS thus formed is lixiviated with H_2O and copper oxide added to the solution.

According to the French Pat. 324609, BaSO_4 is reduced to BaS and the latter converted into BaCO_3 by treating it with CO_2 in the presence of H_2O . The BaCO_3 is then heated with C in an electric furnace and

the BaC_2 thus obtained is finally converted into the hydroxide by treatment with H_2O .

The reaction product (Germ. Pat. 111667 and Amer. Pat. 737740) mentioned above under BARIUM OXIDE, contains besides BaO a considerable amount of BaS . On being lixiviated with water both go into solution, (BaO as Ba(OH)_2 , and BaS partly as barium sulphhydrate and partly as Ba(OH)_2). On cooling, Ba(OH)_2 crystallizes out and can be obtained practically chemically pure by recrystallization.

Finally the Germ. Pat. 129324 may be mentioned. Here Ba(OH)_2 is obtained electrolytically from a conc. BaS solution. The Amer. Pat. 744920, which protects the same electrolytical process, lays stress on the presence of a large porous anode of great resistance (e. g. finely divided iron).

Barium hydroxide is used for the manufacture of caustic alkalis from the sulphates, in analytical chemistry and sometimes in sugar refining.

It forms colourless crystals with 8 mols of water of crystallization, which absorb CO_2 from the air. It dissolves in water to form the strongly alkaline baryta water.

c) BARIUM PEROXIDE BaO_2 . It is obtained from $\text{Ba(NO}_3)_2$ as follows: The $\text{Ba(NO}_3)_2$ is heated in closed fire clay crucibles and thus converted into BaO . Air (free from CO_2) is then allowed to pass over the latter at a dull red heat (about 700°), when BaO_2 is formed. It may also be prepared from BaO which has been obtained by other methods (see above). The commercial product forms a greenish mass; after purification, a colourless powder soluble in H_2O , which absorbs CO_2 from the air. Dilute acids decompose it with the formation of hydrogen peroxide. On being heated, it evolves O and becomes reduced to BaO . It is used for the manufacture of H_2O_2 and O and further as a bleaching agent. The hydrate of barium peroxide can be prepared by dissolving it in some acid e. g. HCl and adding Ba(OH)_2 .

BARIUM CYANIDE Ba(CN)_2 . According to the method of MARGUERITE and SOURDEND Ba(CN)_2 can be prepared by heating a mixture of coal and BaO or BaCO_3 in a steam of N . The product is very impure, a large proportion consisting of barium cyanamide. The method is greatly improved according to the French Pat. 370420 by converting the cyanamide into cyanide by heating to red-heat in a current of hydrocarbons, CO , C_2H_2 , &c.

BARIUM PERCARBONATE. This compound, until recently unknown, can be prepared according to Germ. Pat. 178019 by submitting BaO_2 to the action of CO_2 . The mixture must be kept alkaline and the temperature not allowed to rise above 30° .

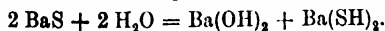
14. BARIUM PERMANGANATE BaMn_2O_8 . It is prepared in the same way as calcium permanganate (see article CALCIUM COMPOUNDS No. 14). Compare also English Pat. 28585 (1903) mentioned above under No. 10 BARIUM MANGANATE.

15. BARIUM PERSULPHATE $\text{BaS}_2\text{O}_8 + 4 \text{H}_2\text{O}$. Obtained by the electrolysis of barium sulphate in sulphuric acid. The persulphate forms crystals which do not deliquesce but gradually decompose into BaSO_4 , especially in a dry atmosphere. The solutions are more stable. 100 pts H_2O dissolve 39 pts anhydrous persulphate at 0° and 52 pts of the crystalline salt.

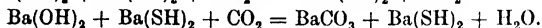
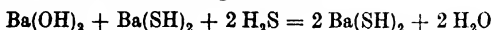
16. BARIUM PLATINOCYANIDE see under PLATINUM COMPOUNDS.

17. BARIUM SULPHATE BaSO_4 see art. on BARIUM COLOURS.

18. BARIUM SULPHIDE BaS . Obtained by the reduction of BaSO_4 with charcoal, tar or oils in furnaces. The anhydrous BaS is phosphorescent. It dissolves in H_2O to form barium sulphhydrate and barium hydroxide



The Germ. Pat. 154498 has for its object the preparation of a barium sulphhydrate which can be used as the starting point for the manufacture of other barium compounds. According to this patent a mixture of heavy spar and coal is ignited and then lixiviated with H_2O . Into the solution of barium hydroxide and barium sulphhydrate thus obtained either H_2S or CO_2 is passed which causes one of the following reactions



In both cases a solution of barium sulphhydrate is obtained from which no sparingly soluble double compounds of this salt with $Ba(OH)_2$ can be separated. The solution is evaporated *in vacuo* and a lye is obtained which is free from polysulphides and can be used for the preparation of other salts.

BaS is used principally for the manufacture of other barium preparations. In exact analysis it is used for the preparation of chem. pure H_2S (free from As).

19. **BARIUM SULPHOCYANIDE** $Ba(CNS)_2$. Obtained by the distillation of ammonium sulphocyanide lyes with caustic baryta at 80° – 90° and 0.2 to 0.4 atm. pressure and then passing in steam. Also obtained by boiling copper sulphocyanide with barium sulphide solution, drawing off the clear solution, and allowing it to crystallize. $Ba(CNS)_2$ crystallizes with $2 H_2O$.

20. **BARIUM THIOSULPHATE** $Ba S_2O_3 + H_2O$. Obtained as a precipitate on mixing solutions of sodium thiosulphate and barium acetate.

21. **BARIUM TUNGSTATE** $BaWO_4$. It is obtained in anhydrous crystals by fusing 2 pts. Na_2WO_4 with 7 pts $BaCl_2$ and 2 pts $NaCl$ and lixiviating with H_2O . It is obtained by the wet method, in the form of large colourless crystals with varying amounts of water of crystallization by precipitating Na_2WO_4 with $BaCl_2$ solutions.

Barium Compounds:

Willy Manger, Dresden, Germany.

Barol. An oil prepared from tar-oil. Its antiseptic properties are increased (Germ. Pat. 121901) by the addition of copper compounds. Brownish-black, very viscous oil, having a faint smell and high S. G. It is used for preserving timber.

Barrels.

Iron barrels:

Kleine, Neuschaefer & Co., Schwelm i. W., Germany.

Barntin. Double salt of barium theobromine and sodium salicylate. Its use depends on the combination of theobromine (diuretic action) and barium (by which the blood-pressure is increased). Barium is used in combination with an organic radical only in this compound.

Basic dyestuffs. Those coal-tar dyes, which are the sulphates, oxalates, chlorides, &c. of organic dye-bases, are termed basic dyes. They dye wool and silk without mordants, in neutral or slightly acid baths; and cotton with the help of acid mordants such as tannin, Turkey red oil &c. The basic dyes are only partly soluble in H_2O but are all soluble in alcohol. As a rule they possess a very great dyeing power and great brilliancy of tone, but are mostly not very fast to light, air and soap.

Although the first aniline dyes all belonged to the basic class, these are now being more and more displaced in cotton and wool dyeing. They are however still of great importance for silk and jute dyeing.

Cotton and linen are usually treated first with tannin and then with tartar emetic solution before being dyed with the basic dyes. The antimony tannate, which is precipitated in the fibre, forms stable lakes with the basic dyes. Instead of these tannin-antimony mordants (see under **TANNIN MORDANTS**),

the cotton may also be treated with Turkey red oil mordants (comp. **TURKEY RED OIL DYEING**). Wool and jute require no mordants, but can be merely dipped into the warm dye-bath. For silk, too, no mordant is necessary; it may be dipped into a slightly acid bath — usually with the addition of boiled-off liquor (prepared by removal of the silk size with neutral soap solution). Such a bath produces warmer shades.

Batteries, galvanic. In the following, the common primary batteries are shortly described according to their arrangement.

With regard to secondary elements see the article "**ACCUMULATORS**".

1. **BECCUEREL'S LEAD SULPHATE CELL.** Zn in ZnSO_4 or dilute H_2SO_4 , Pb in PbSO_4 + dil. H_2SO_4 .
2. **BÖTTGER'S CELL.** Outside Zn in dilute H_2SO_4 ; inside in porous cell carbon rod in $\text{K}_2\text{Cr}_2\text{O}_7$ + HNO_3 of Sp. Gr. 1.3.
3. **BUFF-BUNSEN CELL.** Outside amalgamated Zn in dilute H_2SO_4 ; in porous cell a carbon cylinder in a solution of 12 $\text{K}_2\text{Cr}_2\text{O}_7$, 100 H_2O and 25 Engl. H_2SO_4 . $E = 2$ V.
4. **BUNSEN CELL.** Outside amalgamated Zn in dilute H_2SO_4 ; in a porous cell a carbon rod in conc. HNO_3 of Sp. Gr. 1.3. Very constant element $E = 1.9$ V. It evolves nitrous fumes.
5. **CARRE'S CELL.** Composition is same as in 8 **DANIEL'S** element, with the exception that the diaphragm is not a porous cell but parchment.
6. **CLARK'S NORMAL CELL.** The negative pole is amalgamated Zn, the positive amalgamated Pt; the electrolyte is a paste of conc. ZnSO_4 solution and a solution of mercurous sulphate.
7. **CUPRON CELL.** Plates of CuO hang constantly between two amalgamated Zn plates in sodium hydroxide. The elements supply a current till the CuO is reduced to Cu. The latter can be oxidized again by being washed and dried in a warm place. When not in use the material is not attacked. $E = 0.85$ V.
8. **DANIEL'S CELL.** Outside amalgamated Zn in dilute H_2SO_4 , inside porous cell Cu in saturated CuSO_4 solution. $E = 1.12$ V.
9. **DECKER CELL.** Zn in dil. H_2SO_4 in a flat thin-walled porous pot. Placed in a vulcanite cell containing a graphite electrode in a solution of $\text{Na}_2\text{Cr}_2\text{O}_7$ + H_2SO_4 .
10. **DIPPING CELLS.** Zn and C dip together without a separating membrane in a solution of 125 parts $\text{K}_2\text{Cr}_2\text{O}_7$, 250 Engl. H_2SO_4 , and 1000 H_2O . It is advantageous to add 10 parts HgSO_4 to the solution. According to another formula 75 $\text{K}_2\text{Cr}_2\text{O}_7$ should be taken instead of 125 (the others remaining the same). The use of $\text{Na}_2\text{Cr}_2\text{O}_7$ is also recommended — the mixture then consisting of 125 $\text{Na}_2\text{Cr}_2\text{O}_7$, 125 Engl. H_2SO_4 , and 1000 H_2O . The elements must only remain in the liquid as long as they are needed, and must be raised to avoid unnecessary waste when the cell is not in use.
11. **DRY CELLS.** There are of many different types. The kinds most used are in principle the same as the **LECLANCHÉ'S CELL**. The vessel itself is made of Zn and forms the negative pole, the positive is a C prism around which a mixture of manganese and charcoal is pressed. The exciting liquid is either a ZnCl_2 solution sucked up by saw dust, or a pasty mass of CaCl_2 , NH_4Cl , and ZnSO_4 , or finally a gelatinous mass containing different salts.
An extraordinary example of this type is the **SIEMENS-HALSKE** dry cell (Type I). The inventor has convinced himself of its remarkable resistance and of its recovery after the most irregular evolution of current.
12. **FLASK CELL** see No. 25 dipping element.
13. **GRENET'S DIPPING ELEMENT** see No. 25 dipping element.
14. **GROVE'S CELL.** Outside Zn in dilute H_2SO_4 , inside porous pot Pt in conc. HNO_3 of Sp. Gr. 1.3. $E = 1.8$ V. Very constant cell, but evolves nitrous fumes.

15. HARRISON CELL. Negative pole is amalgamated Zn, the positive hard lead surrounded by PbO_2 . The exciting liquid is 16 % H_2SO_4 ; $E = 2.45 \text{ V}$.

16. JUNGNER CELL. (Norwegian Pat. 16132, 1906). On the bottom of a vessel coated with Pb a layer of pieces of coke is placed, and this is covered with a perforated lead plate. The cathode is a graphite briquette. H_2SO_4 is introduced to about half the height of the briquette, and the whole supported on columns in a larger vessel; the space between the two vessels is closed with a cover. In this cover are zinc tubes for leading off water vapour. The two vessels are placed inside a third vessel and the space between packed with some non-conducting (heat) material. Vigorous action takes place when the electrodes are separated by a porous wall of asbestos, kaolin, slate, &c.

17. LECLANCHÉ'S CELL. In the original arrangement amalgamated Zn was outside in a saturated NH_4Cl solution, inside was a carbon rod in a mixture of granulated charcoal and manganese in a porous pot. Now however the porous cell is left out and instead, a cylinder, pressed out of manganese and charcoal is used. The latter is placed together with the Zn, which it must not touch, in a jar containing an NH_4Cl solution 1 : 4. $E = 1.48 \text{ V}$.

18. MARIE-DAVY CELL. Zn in dilute H_2SO_4 (1 : 20), carbon in a paste of mercurous sulphate and H_2O . $E = 1.52 \text{ V}$.

19. MEIDINGER CELL (BALLOON CELL). In the bottom (narrow) part of the jar a Cu rod stands in a saturated CuSO_4 solution; in the upper (wide) part is a Zn rod in saturated MgSO_4 solution.

20. NORMAL CELL see CLARK'S NORMAL CELL.

21. POST OFFICE CELL see TELEGRAPHIC CELL.

22. SIEMENS-HALSKE CELL see No. 26.

23. SILVER CHLORIDE CELL. Amalgamated Zn is the negative pole; the positive, which stands in a cell of parchment paper, consists of a sheet of silver surrounded by AgCl . The exciting liquid is either NH_4Cl solution or NaCl solution.

24. SMEE'S CELL. Platinized Zn plate between two amalgamated Zn plates; all three stand together without diaphragm in H_2SO_4 . 1 : 2.

25. TELEGRAPHIC CELL. The negative pole is Zn in saturated ZnSO_4 solution, the positive a copper-plated Pb plate in CuSO_4 solution (with CuSO_4 crystals). The liquids separate because of the different Sp. Gr., on which account the cell must be kept undisturbed. A diaphragm is not needed.

Bearing metals. Alloys for the preparation of bearings for the moving parts of machines; they must run with very little friction and offer great resistance to high pressures. A distinction is made between bearing metals which consist of a Cu-Sn alloy with a small amount of Zn, and those which contain, besides antimony and lead, small amounts of Cu and Sn. The former are called "red-brass" or "machine bronze" (see under "BRONZES" and "COPPER ALLOYS"). The latter are termed "white metal" or "antifriction metal" (see under ANTIMONY ALLOYS).

Red brass bearing metals contain about 82–89 % Cu and 11–18 % Sn; a certain amount of hardness and ductility may be given to the red brass by the addition of Sn and Zn. If hardness and strength are required then bearing metals rich in copper must always be chosen. Thus for instance a well tried red brass bearing metal for locomotive axles consists of 89 % Cu, 7.8 % Zn, 2.4 % Sn, and 0.8 % Fe; another of 85.3 % Cu, 2.0 % Zn, and 12.7 % Sn; a third of 73.5 % Cu, 9.0 % Zn, 9.5 % Sn, 7.5 % Pb, and 0.5 % Fe.

White bearing metals are more readily fusible than those rich in Cu; they also do not wear away the plugs and shafts so much on account of their softness. But even in spite of this the durability is almost the same if the composition is correct; however they will not stand heating of the axle bearings due to improper lubrication. Railway bearing metals consist for

Table of brewing processes.

Process	Place or Apparatus	Time	Object of the Process
I. MALTING.			
1. Clearing of the Barley.	Revolving Malt-screens.	—	Removal of Dust, Seeds of Weeds, Broken Corns, etc.
2. Steeping of the Barley.	Steeping Tanks or cisterns.	About 3 days.	Supplying the Barley with the Water required for growth.
3. Germination of the Steeped Barley („Flooring”).	Malting-floor.	7 to 10 days.	Loosening of the Mealy Substance of the Barley and Conversion of its Albuminoids into the Ferment Diastase.
4. Kiln-drying of the Germinated Barley.	Malt-kiln.	16 or 24 hours.	Arrest of Germination. Formation of Substances important for the flavour of Beer and the Feeding of Yeast.
5. Clearing of the Malt.	Rotary Sieves.	—	Removal of Radicles and Dust.
6. Crushing of the Malt.	Malt Mill.	—	Comminution of the Malt Grains in order to present a larger surface to the action of the Water in Mashing.
II. BREWING.			
7. Mashing.	Brewing-house Appliances: 1. Mash-tun. 2. Decoction Pan.	4 to 5 hours.	Change of the Starch of the Crushed Malt into a Saccharine Extract by the Heating of the Mash in the Mash-tun. The Heating takes place in stages; three times in succession a portion of the mash is boiled in the Decoction pan and then pumped back into the mash-tun (decoction process).
8. Filtration.	3. Filtration-tub with a bottom of perforated metal.	2 to 4 hours.	Separation of the sweet wort from malt husks, and filtration of the former through the layer of the luter. The filtered wort runs into the wort copper; the residue is washed out with hot water and forms a nitrogenous cattle food.
9. Boiling of the Wort.	4. Wort Copper.	2 hours.	Boiling of the Wort after mixing with the washing waters and after addition of hops.
10. Separation of the Wort from the Spent hops.	5. Hopback.	—	
11. Cooling of the Wort.	Cooler and Refrigerator.	3 to 5 hours.	Cooling and clearing of the boiling wort; reduction to temperature of fermentation (6,2° C or 43,2° F).
III. FERMENTATION.			
12. Primary Fermentation.	Fermenting-house. Fermenting-tuns.	7 to 14 days.	Ferment: Yeast. Formation of Alcohol and carbonic acid. Deposition of most of the added and newly formed Yeast.
13. Secondary Fermentation.	Storage Cellar. Storage Casks.	6 to 8 weeks.	Deposition of the Yeast-cells, etc., and Clearing. Saturation with carbonic acid while cooling to the Cellar temperature (1,25—2,5° C or 34,25—36,5° F).
14. Bunging.	—	About 8 days.	Supersaturation with the carbonic acid, formed during the secondary fermentation under pressure in the cask, in order to produce the foam in retailing.
15. Barrelling and Marketing.			

example of 80 % Sn, 12 % Sb, and 8 % Cu, others of 14 % Sn, 80 % Sb, 5 % Cu, and 1 % Ni, others again of 42 % Sn, 16 % Sb, and 42 % Pb, or of 12 % Sn, 20 % Sb, 8 % Cu and 60 % Pb. It was formerly thought that the quality of the white bearing metals was worse the higher the S. G. which is influenced in this direction by the percentage of Pb; but recently the white metals rich in lead have been preferred. For example, the following bearing metals, which contain approx. 78 % Pb, possess excellent properties. — Gly metal, atlas metal, magnolia metal, and myrtle antifriction metal.

Becquerel rays see RADIOACTIVE SUBSTANCES.

Beech wood charcoal see WOOD TAR and CHARCOAL BURNING.

Beech wood tar see WOOD TAR and CHARCOAL BURNING.

Beer. Raw materials for beer brewing are barley, hops and water. The separate operations in brewing are collected into the following table taken from POSSANNER (Chem. Technologie der landw. Gewerbe. Teil I).

The water used for malting and the preparation of wort must be at least equal to good drinking water. A certain hardness in the water seems to be rather advantageous than otherwise, at least in so far as the hardness is the result of gypsum; a too high percentage however reduces the extra yield. The following may be considered reliable limits for the water for brewing purposes:— 1 l water must not contain more than 500 mg total solids, 112 mg CaO, 40 mg MgO, 80 mg SO₃, 35 mg Cl, 27 mg N₂O₅; at the most 0.008 grms KMnO₄ must be necessary to oxidize the organic matter. The hardness must not exceed 16—18 German degrees of hardness; NH₃ and N₂O₃ must be absent. It is especially important that the water should contain very few micro-organisms, especially such as would multiply in the wort and thus impair the quality. An ozone-sterilisation plant is recommended for rendering water which contains a large number of bacteria serviceable for breweries, as well as for destroying the harmful SARCINA, which are often found in brewery waters during the summer months.

With regard to malting see article on MALT.

The real brewing process may be divided into

1. Preparation of the wort,
2. Boiling the wort with hops,
3. Cooling the wort.

The wort is obtained by mixing the crushed malt with H₂O and heating to 75°. MASHING. In Germany the thick-mashing process (decoction process) is almost exclusively practised. In this, the thicker part of the mash is ladled out and heated to boiling in a special mashing boiler, and then emptied back into the mashing tub until the mash has reached the temperature of 75°.

The following apparatus are used.

1. FORE-MASHING APPARATUS for mixing the crushed malt with cold water.
2. MASHING TUB, used for mashing, and also for clarifying (in smaller breweries).

3. CLARIFYING VATS, only used in factories on a large scale. The wort is strained through metal sieves, that is it is separated from the grains, and the latter treated with H₂O. As already mentioned, the mash tub is also used in small works as a clarifying vat. Recently filtration of the mash has been more and more recommended; such mash-filters can be used directly in place of the clarifying vats.

4. MASHING BOILERS (thick mashing boilers), for heating the thicker part of the mash.

5. WORT PAN (brewing boiler) usually with a stirring arrangement; for boiling the wort with hops. A heater produces the necessary hot water.

6. HOP STRAINER. With regard to hops see special article. The hop strainer is used for removing the hops from the finished wort.

7. COOLING ARRANGEMENTS. The finished wort must be cooled as quickly as possible to 5° (for slightly fermented beers), for which coolers (that is, large flat iron vessels) are generally used; horizontal sails accelerate the action. Recently, surfaces cooled by trickling water have been used with advantage, partly as a substitute and partly to perfect the cooling pans. The apparatus, which prevents the entrance of air (and, in doing so, the possibility of infection with micro-organisms) during the boiling, sterilisation, and cooling, are still more advantageous.

The concentration of the finished beer-wort is usually expressed in degrees of the BALLING's saccharometer. This gives the percentage of a cane sugar solution of 17.5°, but may however also be used for worts without any special errors, seeing that the density of the wort is influenced by the dry substance practically in the same way as the sp. Gr. of a sugar solution is by the sugar.

The checking of the amount of extract of the wort is necessary in the first place in order to ascertain the yield from the malt, and in the second place to bring the wort up to the required value.

The following tables show the relations between saccharometer degrees BALLING and the S. G.

Conversion of saccharometer degrees BALLING into S. G.

Saccharometer degrees	Corresponding S. G. at 17.5° C	Saccharometer degrees	Corresponding S. G. at 17.5° C	Saccharometer degrees	Corresponding S. G. at 17.5° C	Saccharometer degrees	Corresponding S. G. at 17.5° C	Saccharometer degrees	Corresponding S. G. at 17.5° C	Saccharometer degrees	Corresponding S. G. at 17.5° C
0.0	1.000	3.4	1.014	6.8	1.027	10.2	1.041	13.6	1.056	17.0	1.070
0.2	1.001	3.6	1.014	7.0	1.028	10.4	1.042	13.8	1.056	17.2	1.071
0.4	1.002	3.8	1.015	7.2	1.029	10.6	1.043	14.0	1.057	17.4	1.072
0.6	1.002	4.0	1.016	7.4	1.030	10.8	1.044	14.2	1.058	17.6	1.073
0.8	1.003	4.2	1.017	7.6	1.031	11.0	1.045	14.4	1.059	17.8	1.074
1.0	1.004	4.4	1.018	7.8	1.031	11.2	1.046	14.6	1.060	18.0	1.074
1.2	1.005	4.6	1.018	8.0	1.032	11.4	1.046	14.8	1.061	18.2	1.075
1.4	1.006	4.8	1.019	8.2	1.033	11.6	1.047	15.0	1.061	18.4	1.076
1.6	1.006	5.0	1.020	8.4	1.034	11.8	1.048	15.2	1.062	18.6	1.077
1.8	1.007	5.2	1.021	8.6	1.035	12.0	1.049	15.4	1.063	18.8	1.078
2.0	1.008	5.4	1.022	8.8	1.036	12.2	1.050	15.6	1.064	19.0	1.079
2.2	1.009	5.6	1.022	9.0	1.036	12.4	1.051	15.8	1.065	19.2	1.080
2.4	1.010	5.8	1.023	9.2	1.037	12.6	1.051	16.0	1.066	19.4	1.081
2.6	1.010	6.0	1.024	9.4	1.038	12.8	1.052	16.2	1.067	19.6	1.081
2.8	1.011	6.2	1.025	9.6	1.039	13.0	1.053	16.4	1.067	19.8	1.082
3.0	1.012	6.4	1.026	9.8	1.040	13.2	1.054	16.6	1.068	20.0	1.083
3.2	1.013	6.6	1.026	10.0	1.040	13.4	1.055	16.8	1.069		

If the saccharometer degree of the wort be called s , the corresponding S. G. D and the amount of extract we have to find (E) (in kilogrammes per 1 lit. wort), then $\frac{100}{s} = \frac{D}{E}$; $E = \frac{D \cdot s}{100}$. If q litres of wort have been obtained from p kilogram malt then the yield of extract from 100 pts malt (that is, also in %) = $\frac{q \cdot E \cdot 100}{p}$. If the wort is measured instead of weighed (as in Bavaria), then we must take into consideration 1 l malt = 0.513 kg.

Reduction of the specific gravities to saccharometer degrees (Balling).

	0	1	2	3	4	5	6	7	8	9
1.008	2.000	2.025	2.050	2.075	2.100	2.125	2.150	2.175	2.200	2.225
1.009	2.250	2.275	2.300	2.325	2.350	2.375	2.400	2.425	2.450	2.475
1.010	2.500	2.525	2.550	2.575	2.600	2.625	2.650	2.675	2.700	2.725
1.011	2.750	2.775	2.800	2.825	2.850	2.875	2.900	2.925	2.950	2.975
1.012	3.000	3.025	3.050	3.075	3.100	3.125	3.150	3.175	3.200	3.225
1.013	3.250	3.275	3.300	3.325	3.350	3.375	3.400	3.425	3.450	3.475
1.014	3.500	3.525	3.550	3.575	3.600	3.625	3.650	3.675	3.700	3.725
1.015	3.750	3.775	3.800	3.825	3.850	3.875	3.900	3.925	3.950	3.975
1.016	4.000	4.025	4.050	4.075	4.100	4.125	4.150	4.175	4.200	4.225
1.017	4.250	4.275	4.300	4.325	4.350	4.375	4.400	4.425	4.450	4.475
1.018	4.500	4.525	4.550	4.575	4.600	4.625	4.650	4.675	4.700	4.725
1.019	4.750	4.775	4.800	4.825	4.850	4.875	4.900	4.925	4.950	4.975
1.020	5.000	5.025	5.050	5.075	5.100	5.125	5.150	5.175	5.200	5.225
1.021	5.250	5.275	5.300	5.325	5.350	5.375	5.400	5.425	5.450	5.475
1.022	5.500	5.525	5.550	5.575	5.600	5.625	5.650	5.675	5.700	5.725
1.023	5.750	5.775	5.800	5.825	5.850	5.875	5.900	5.925	5.950	5.975
1.024	6.000	6.024	6.048	6.073	6.097	6.122	6.146	6.170	6.195	6.219
1.025	6.244	6.268	6.292	6.316	6.341	6.365	6.389	6.413	6.438	6.463
1.026	6.488	6.512	6.536	6.560	6.584	6.609	6.633	6.657	6.681	6.706
1.027	6.731	6.756	6.780	6.804	6.828	6.853	6.877	6.901	6.925	6.950
1.028	6.975	7.000	7.024	7.048	7.073	7.097	7.122	7.146	7.170	7.195
1.029	7.219	7.244	7.268	7.292	7.316	7.341	7.365	7.389	7.413	7.438
1.030	7.463	7.488	7.512	7.536	7.560	7.584	7.609	7.633	7.657	7.681
1.031	7.706	7.731	7.756	7.780	7.804	7.828	7.853	7.877	7.901	7.925
1.032	7.950	7.975	8.000	8.024	8.048	8.073	8.097	8.122	8.146	8.170
1.033	8.195	8.219	8.244	8.268	8.292	8.316	8.341	8.365	8.389	8.413
1.034	8.438	8.463	8.488	8.512	8.536	8.560	8.584	8.609	8.633	8.657
1.035	8.681	8.706	8.731	8.756	8.780	8.804	8.828	8.853	8.877	8.901
1.036	8.925	8.950	8.975	9.000	9.024	9.048	9.073	9.097	9.122	9.146
1.037	9.170	9.195	9.219	9.244	9.268	9.292	9.316	9.341	9.365	9.389
1.038	9.413	9.438	9.463	9.488	9.512	9.536	9.560	9.584	9.609	9.633
1.039	9.657	9.681	9.706	9.731	9.756	9.780	9.804	9.828	9.853	9.877
1.040	9.901	9.925	9.950	9.975	10.000	10.023	10.047	10.071	10.095	10.119
1.041	10.142	10.166	10.190	10.214	10.238	10.261	10.285	10.309	10.333	10.357
1.042	10.381	10.404	10.428	10.452	10.476	10.500	10.523	10.547	10.571	10.595
1.043	10.618	10.642	10.666	10.690	10.714	10.738	10.761	10.785	10.809	10.833
1.044	10.857	10.881	10.904	10.928	10.952	10.976	11.000	11.023	11.047	11.071
1.045	11.095	11.119	11.142	11.166	11.190	11.214	11.238	11.261	11.285	11.309
1.046	11.333	11.357	11.381	11.404	11.428	11.452	11.476	11.500	11.523	11.547
1.047	11.571	11.595	11.619	11.642	11.666	11.690	11.714	11.738	11.761	11.785
1.048	11.809	11.833	11.857	11.881	11.904	11.928	11.952	11.976	12.000	12.023
1.049	12.047	12.071	12.095	12.119	12.142	12.166	12.190	12.214	12.238	12.261
1.050	12.285	12.309	12.333	12.357	12.381	12.404	12.428	12.452	12.476	12.500
1.051	12.523	12.547	12.571	12.595	12.619	12.642	12.666	12.690	12.714	12.738
1.052	12.761	12.785	12.809	12.833	12.857	12.881	12.904	12.928	12.952	12.976
1.053	13.000	13.023	13.047	13.071	13.095	13.119	13.142	13.166	13.190	13.264
1.054	13.238	13.261	13.285	13.309	13.333	13.357	13.381	13.404	13.428	13.452
1.055	13.476	13.500	13.523	13.547	13.571	13.595	13.619	13.642	13.666	13.690
1.056	13.714	13.738	13.761	13.785	13.809	13.833	13.857	13.881	13.904	13.928
1.057	13.952	13.976	14.000	14.023	14.047	14.071	14.095	14.119	14.142	14.166
1.058	14.190	14.214	14.238	14.261	14.285	14.309	14.333	14.357	14.381	14.404
1.059	14.428	14.452	14.476	14.500	14.523	14.547	14.571	14.595	14.619	14.642
1.060	14.666	14.690	14.714	14.738	14.761	14.785	14.809	14.833	14.857	14.881
1.061	14.904	14.928	14.952	14.976	15.000	15.023	15.046	15.070	15.093	15.116
1.062	15.139	15.162	15.186	15.209	15.232	15.255	15.278	15.302	15.325	15.348
1.063	15.371	15.395	15.418	15.441	15.464	15.488	15.511	15.534	15.557	15.581
1.064	15.604	15.627	15.650	15.674	15.697	15.721	15.744	15.767	15.790	15.814

	0	1	2	3	4	5	6	7	8	9
1.065	15.837	15.860	15.883	15.907	15.930	15.953	15.976	16.000	16.023	16.046
1.066	16.070	16.093	16.116	16.139	16.162	16.186	16.209	16.232	16.255	16.278
1.067	16.302	16.325	16.348	16.371	16.395	16.418	16.441	16.464	16.488	16.511
1.068	16.534	16.557	16.581	16.604	16.627	16.650	16.674	16.697	16.721	16.744
1.069	16.767	16.790	16.814	16.837	16.860	16.883	16.907	16.930	16.953	16.976
1.070	17.000	17.022	17.045	17.067	17.090	17.113	17.136	17.158	17.181	17.204
1.071	17.227	17.250	17.272	17.295	17.318	17.340	17.363	17.386	17.409	17.431
1.072	17.454	17.477	17.500	17.522	17.545	17.568	17.590	17.613	17.636	17.659
1.073	17.681	17.704	17.727	17.750	17.772	17.795	17.818	17.841	17.863	17.886
1.074	17.909	17.931	17.954	17.977	18.000	18.022	18.045	18.067	18.090	18.113
1.075	18.137	18.158	18.181	18.204	18.227	18.250	18.272	18.295	18.318	18.340
1.076	18.363	18.386	18.409	18.431	18.454	18.477	18.500	18.522	18.545	18.569
1.077	18.590	18.613	18.636	18.650	18.681	18.704	18.724	18.750	18.772	18.795
1.078	18.818	18.841	18.863	18.886	18.909	18.931	18.954	18.977	19.000	19.022
1.079	19.045	19.067	19.090	19.113	19.136	19.158	19.181	19.204	19.227	19.250

If the saccharometer sample is not taken at 17.5°, but at some other temperature, then the reading must be reduced to the normal temperature of 17.5° C. according to following table.

De- grees C	Correction	De- grees C	Correction	De- grees C	Correction	De- grees C	Correction
4	— 0.43	11	— 0.22	17.5	0	24	+ 0.27
5	— 0.40	12	— 0.19	18	+ 0.02	25	+ 0.32
6	— 0.37	13	— 0.16	19	+ 0.05	26	+ 0.37
7	— 0.34	14	— 0.13	20	+ 0.09	27	+ 0.42
8	— 0.31	15	— 0.10	21	+ 0.13	28	+ 0.48
9	— 0.28	16	— 0.06	22	+ 0.17	29	+ 0.54
10	— 0.25	17	— 0.02	23	+ 0.22	30	+ 0.60

To convert the wort into beer it is made to ferment by the addition of yeast, by which means the sugar (maltose) is split into alcohol and CO₂.

With regard to yeast, pure cultivation and apparatus, see special article on YEAST.

A distinction is made between highly fermented and slightly fermented beers. The former fermentation takes place at 12—19° C. rather quickly by which the yeast is driven to the surface by the CO₂. With the exception of the English beers porter and ale, it may be said that the highly fermented beers are less stable than the slightly fermented (brewed according to Bavarian or Bohemian style). The light fermentation takes place very slowly at a temperature of 5—10°. The yeast settles then on the bottom (under yeast).

The fermenting vats are usually made of wood. The cooling of the fermenting cellar is carried out either by means of natural ice or by freezing machines. Either the whole cellar or each separate vat is cooled. After the principal fermentation, the beer undergoes in the store cellar at 0° another after-fermentation. During this it is drawn off into transport barrels and bunged in order to increase the amount of CO₂. On being drawn off it is usually sent through a filter press to render it perfectly clear.

To make the beer keep better, it is either brewed stronger or the finished beer is pasteurised by heating in stoppered bottles to 50°—60°. Concerning pasteurisation see also „MILK” and „PRESERVATION.” With regard to the size of the apparatus necessary for brewing, the following are needed for 1 hl of mash.

1.40 hl mashing tub room, 0.70 hl mash boiler room, 1.66 hl clarifying vat-room, 1.45 hl wort panroom.

The fermenting vats are manufactured in different sizes of 18—40 hl. The capacity of the oak store barrels, the interior of which is pitched, varies between 20—80 hl. The barrels are stored in two rows, one above the other. Then for 1 sq. met. cellar floor is reckoned, for small barrels 12 hl store beer, for average barrels 13 hl store beer and for very large barrels 14 hl store beer. The amount of pitch necessary for pitching amounts to 0.3—0.7 kg for every 1 hl capacity of barrel.

The brewers' grains left after mashing are dried in a special apparatus and form an excellent feeding material

Of late years WEBER has recommended fermenting vats of glass instead of those of wood. The taste of the beer produced in glass vats is said to be much purer than that made in wooden tubs, and the vessels can be more quickly and thoroughly cleaned.

On the other hand the surfaces of metallic vessels, especially those of iron, in which beer is made or stored are coated with a layer of oleates which is obtained by boiling the vessels with linseed oil or castor oil. According to the Germ. Pat. 153505 the metallic surface is treated first with tannic acid and then coated with a varnish. On the other hand the Germ. Pat. 154405 specifies that the vessels are first to be treated with tannic acid, and then boiled as above with linseed oil, castor oil or rectified resin oil.

The Germ. Pat. 158841 alters the latter process in such a way that after the surfaces have been treated with tannic acid and with oil, the vessels are exposed to the action of hot compressed air at 350°—400°.

Quite a sensation has been created by NATHAN's new process of making beer (Germ. Pat. 135539), according to which a beer of good taste is obtained within 8 days. The method depends on the fact that a very rapid development of alcohol is brought about by stirring and continually passing air through the wort. The pleasant tasting aromatic substances are also quickly formed, and the so-called young bouquet is removed without storing. One condition however, is that the apparatus must be kept completely sterile, on which account only closed enamelled vessels, which are easy to clean, can be employed. The principal apparatus in the process (called the Hansena apparatus) has a capacity of 12000 l and is covered with a five-fold glass layer, which has been fused at a high temperature to the interior wall of the yeast vessel. The enamel must not only be acid proof but also unaffected by great differences of temperature and must not be fragile. The hot wort is brought into the Hansena apparatus, agitated by a long enamelled stirring shaft, and cooled by means of the water which flows through the mantle. The wort absorbs simultaneously at its surface filtered sterile air. When the temperature has fallen to 50° the stream of air is shut off and CO₂ is allowed to enter the vessel.

Then the temperature is allowed to fall to 10°, the yeast drawn in by means of a vacuum pump, and agitated a few minutes every hour by the stirrer. The CO₂ which is developed is drawn off, purified and liquefied. As soon as the beer shows "head" the yeast is allowed to set and is removed from the apparatus in a thick form. Then it is heated to about 15°, CO₂ blown in through the bottom, and the mass constantly agitated. The CO₂ is drawn off at the top, purified and allowed to enter again. In this way the disagreeable and unpleasant tasting substances, which are all volatile, are removed. The beer is then cooled, saturated with CO₂ and passed through a filter and is ready for sale.

Preservatives:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London S.E.

Yeast:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London S.E.

Brewer's Materials:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London S.E.

Brewing Pans:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Bees' honey see HONEY.

Bees' wax see WAX.

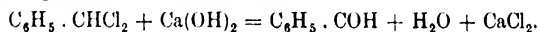
Beet-root molasses see "MOLASSES".

Beet-root sugar see SUGAR MANUFACTURE AND SUGARS.

Bellite see SAFETY EXPLOSIVES.

Benzal chloride $C_6H_5 \cdot CHCl_2$ (BENZYLIDENE CHLORIDE). It is obtained technically by the action of chlorine on boiling toluene $C_6H_5 \cdot CH_3 + 2 Cl_2 = C_6H_5 \cdot CHCl_2 + 2 HCl$. Benzyl chloride and other chlorine substitution products are also formed by this reaction. Rectification is however not generally carried out commercially because benzal chloride is merely an intermediate product in the manufacture of benzaldehyde, benzoic acid and cinnamic acid.

Benzaldehyde (BITTER ALMOND OIL) $C_6H_5 \cdot COH$. Until recently it was obtained commercially almost entirely from benzal chloride by heating the latter under pressure with milk of lime



It is distilled with steam, purified with sodium bisulphite and again distilled. Of late years the Germ. Pat. 154499 has become very important. According to this, benzaldehyde may be obtained directly from benzene by treating the latter, in the presence of Cu or cuprous chloride and aluminium bromide or iodide, with a mixture of carbon monoxide and HCl or HBr.

Finally benzaldehyde may be obtained by the oxidation of toluene, and in this connection the Germ. Pat. 154499 is important. According to this, aqueous sulphurous acid is used instead of alkali bisulphite for the manufacture of pure aromatic aldehydes which are insoluble in H_2O , and the purified aldehydes are then precipitated from the clear solution thus obtained. For example, by the oxidation of toluene with PbO_2 and H_2SO_4 a crude product is obtained which contains, besides 60 % unaltered toluene, 40 % benzaldehyde. 100 kg of this product are well mixed with 400 l. H_2O at 15° and into the emulsion 25—30 kgs sulphurous acid are passed. The remaining insoluble toluene is then separated from the aqueous solution of aldehyde sulphite and the latter gradually heated to 100° with the object of obtaining the aldehyde. Above 30° , sulphurous acid is liberated, and is at once used for future work. On cooling, 36—38 kg of pure benzaldehyde separate. By using the water from the benzaldehyde for the next charge the small amount of benzaldehyde which remains dissolved in H_2O is regained.

Clear strongly refracting liquid, S. G. 1.0504. B. P. 179.2° insoluble in H_2O very readily soluble in alcohol and ether, oxidizes in the air to benzoic acid. Benzaldehyde is used for the preparation of numerous tar dyes.

Benzanalgene see ANALGENE.

Benzene (BENZOL) C_6H_6 . This important constituent of coal tar can be obtained now-a-days in much greater quantities seeing that coal tar is no longer obtained only in the manufacture of gas but also as a by-product in the coke industry. It is to the interest of the gas manufacturers that the benzene which is the chief illuminant in coal-gas, should remain as far as possible in the latter; whereas in the coking process, this factor does not enter, seeing that the heating effect of the gases is the only thing that comes into consideration, and this is in no way influenced by the absence of benzene. For this reason, in the manufacture of coke not only is benzene obtained from the tar, but also the gases before being returned to the coke furnaces are subjected to a special treatment with the object of separating the benzene.

This separation is carried out either with the help of cooling apparatus, which causes benzene to solidify, or according to BRUNCK'S method, by washing the gas with oils of high boiling point which retain the benzene.

Benzene is obtained from coal-tar by fractional distillation (see article COAL TAR). The commercial product is not pure but contains various impurities. The rectification is generally carried out so that three fractions are obtained viz. 90 % benzene, 50 % benzene and solvent naphtha; with regard to latter see special article. The commercial 50 % benzene must contain 50 % of constituents which volatilize below 100°, and the 90 % benzene must contain 90 % of such constituents. By the further fractionation of the 50 % benzene, which is generally carried out in a column apparatus 30—40 % of pure benzene may be obtained, 5 % of so called "benzene for red" (i. e. a mixture of benzene and toluene) 35—40 % pure toluene and 5—8 % xylene, whereas from the 90 % benzene the following may be obtained 65—75 % pure benzene, 10 % "benzene for red", and 2—4 % toluene and xylene.

The column apparatus used in the separation of pure hydrocarbons are fitted with dephlegmators and resemble those employed in the rectification of alcohol. The Germ. Pat. 140824 protects a rectification column for benzene which is said to be characterised by the small consumption of H_2O and steam. The vapours enter the rectification column at the top and not as usual at the bottom. The separation of vapour and condensed liquid is carried out by means of peculiarly constructed shelves.

NIKIFOROW'S process for obtaining aromatic hydrocarbons (especially benzene) from crude mineral oil is also important. According to this process, which is patented in almost all countries, the mineral oil is distilled in horizontal iron retorts first at 500° and then under increased pressure at 1000°. In this way 12 % of the crude oil taken is obtained in the form of benzene and toluene, 1 % as anthracene and 2—3 % as naphthalene. The waste products consisting of gas, coke and heavy oil are used as fuel.

This process can only be used where large quantities of mineral oil are available at small cost; and even then, taking into consideration the low price of benzene there is little prospect of success (Germ. Pat. 143549). It should be noted that this patent does not concern the real process for obtaining aromatic hydrocarbons but merely the arrangement for purification.

Of the different methods for purifying benzene that of SCHWALBE (Germ. Pat. 133761) may be mentioned. It has as its object the separation of the sulphur compounds, especially carbon disulphide and thiophene, from crude benzene, by the action of moist ammonia under ordinary or increased pressure. Oily drops are formed which collect under the benzene; the washed benzene is thus obtained perfectly free from sulphur compounds.

The removal of thiophene is also attempted by the processes of 1. DIMROTH and 2. VON LIPPMANN and POLLAK. In the first-named process the boiling benzene is treated with a solution of mercuric acetate, and in the second, with sulphur chloride. These reagents form compounds with the thiophene while the benzene itself is not attacked.

Pure benzene is a mobile, colourless liquid of peculiar smell; S. G. 0.8841 at 15°; B. P. 80.5°. It solidifies at 0° forming large rhombic crystalline plates which melt at 3°. It is miscible with alcohol, ether, acetone &c., and is almost insoluble in H₂O, readily inflammable, burns with a luminous smoky flame, dissolves fats, volatile oils, caoutchouc, guttapercha, camphor, &c. Chemically pure benzene is obtained by the distillation of benzoic acid with quicklime.

Benzene is the starting point for the preparation of very many aromatic compounds. It is further used as a solvent and purifying agent for numerous organic substances and is now especially important as the starting point for the synthetic preparation of indigo; compare INDIGO DYES.

The following table shows the products of commercial benzene at different temperatures.

Commercial name	Yields at				S. G. at 15°
	100° °/o	120° °/o	130° °/o	160° °/o	
90 % benzene	90	100	—	—	0.885
50 % "	50	90	—	—	0.880
30 % "	30	90	—	—	0.875
Solvent naphtha (heavy benzene)	—	—	20	90	0.875

The French Pat. 348501 treats of the manufacture of benzene emulsions. Such benzene-water mixtures are much less inflammable than the pure hydrocarbon.

Solid benzene is also manufactured in a manner similar to that by which benzine, petroleum and spirits are rendered solid. (Comp. articles on BENZINE, MINERAL OIL and HARD SPIRITS.)

Benzene:

Forbes, Abbott & Lennard Ltd., 85 Gracechurch St., London E.C.

Benzene apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Benzene, benzoyl, and benzyl compounds.

Only a few of the following derivatives will be mentioned in so far as they are of technical importance and are not treated in separate articles.

The following are separately treated:—

ANILINE, ANILINE DERIVATES, BENZALCHLORIDE, BENZALDEHYDE, BENZOIC ACID, BENZOTRICHLORIDE, BENZYLCHLORIDE, CATECHOL, CUMENE CUMIDINE, DINITROBENZENE, DIPHENYLAMINE, HYDROQUINONE, NITROBENZALDEHYDE, NITROBENZENE, PHENOLPHTHALEIN, PHENYLENDIAMINE, PHENOL, RESORCINOL, SALICYLIC ACID, SULPHANILIC ACID, TOLUENE (with NITRO- and AMIDOTOLUENES), TOLUIDINE, TOLIDINE, XYLENE and XYLIDINES; for information with regard to these substances the separate articles must be consulted. BENZOPHENONE see under KETONES; BENZYLACETATE see under PERFUMES, ARTIFICIAL.

1. AMIDOBENZENE SULPHONIC ACIDS $\text{NH}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{SO}_3\text{H}$. The ortho-acid is obtained by the reduction of o-nitrobenzenesulphonic acid, and forms rhombohedral crystals. The meta acid is also obtained by the reduction of m-nitrobenzenesulphonic acid and forms crystals which dissolve in 68 pts H₂O at 50°. The m-amidobenzenesulphonic acid is also termed metanilic acid. Technically the most important is the p-amidobenzenesulphonic acid, which has the name sulphanilic acid. It is treated of in a special article.

2. **BENZENESULPHONIC ACID** $C_6H_5 \cdot SO_3H$. Obtained by boiling benzene with fuming sulphuric acid for a long time, using a reflux condenser. Forms very deliquescent fine needles.

3. **BENZOYL PEROXIDE** $(C_6H_5 \cdot CO \cdot O)_2$. It is obtained by treating Na_2O_2 with the equivalent amount of benzoylchloride. It forms prisms sparingly soluble in water M. P. 103.5° and is said to be used medicinally as an antiseptic, in the form of a powder, as an ointment or as a 10 % solution.

4. **BENZYL ALCOHOL** $C_6H_5 \cdot CH_2 \cdot OH$. May be obtained by treating benzaldehyde with sodium amalgam or alcoholic potash; is however usually prepared from Peru balsam, in which it occurs to a small extent in the free state but mainly combined with benzoic acid (and cinnamic acid). It is prepared by heating Peru balsam with four times its amount of KOH until a clear solution is obtained, from which the solid part is removed on cooling, while the remaining liquid is distilled with water. Benzyl alcohol passes over and is separated from the distillate by extraction with ether. Recently it has been obtained from toluene. According to the French Pat. 348951 it may be obtained by the electrolytic reduction of benzoic acid ester using pure lead cathodes.

Benzyl alcohol forms an aromatic smelling liquid of S. G. 1.0507 (at 15°), B. P. 206.5° .

Benzene-Benzoyl- and Benzyl-compounds apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Benzidine (p. DIAMIDODIPHENYL) $NH_2 \cdot C_6H_4 \cdot C_6H_4 \cdot NH_2$. Obtained by the reduction of p. nitrodiphenyl with zinc dust in alkaline solution; also by the electrolysis of nitrobenzene. It is also obtained by electrolysis azoxybenzene in hydrochloric acid solution with the addition of $SnCl_2$, or by using a zinc cathode (Germ. Pat. 116467 and 122046).

Pure benzidine forms colourless plates M. P. 122° . Very sparingly soluble in cold H_2O , readily soluble in hot; also readily soluble in alcohol and ether. It forms salts with acids and is used for the preparation of many dyes.

Benzine. Different benzines are to be distinguished, coal tar benzene, brown-coal benzene, and petroleum benzene. Coal-tar benzene is now generally termed benzene (see this), while brown-coal benzene is generally known under the name SOLAR OIL (see this); by benzene (ligroine) is always understood simply petroleum benzene. For the preparation of benzene, see the article MINERAL OILS. The crude benzene is purified by first distilling it, after which follows a chemical purification consisting of washing first with conc. H_2SO_4 and then with NaOH. According to the Germ. Pat. 141298 the unpleasant smell of petroleum benzene is removed by adding about 1 % volatile oils which contain turpentine, heating the mixture to 70° , and then thoroughly shaking with 2.5 % NaOH of 35° Bé.; the unpleasant smelling constituents are said to be condensed, by means of the alkali, with the turpentine to form odourless compounds. Other similar processes have been proposed and patents applied for. Thus according to the English Pat. 10004 (1903) benzene is treated at a low temperature with solutions of permanganates, persulphates or chromic acid.

Pure benzene is known as petroleum ether.

Recently experiments have been made with a view of preparing solid benzene in a manner similar to that in which spirits are converted into a solid form (comp. "SOLID SPIRITS"). Thus for example, according to Amer. Pat. 641962, in order to solidify petroleum hydrocarbons, about 91 pts (by wt.) of the latter are mixed with 7 pts. Kernseife and 2 pts stearine, the mixture heated until soap and stearine are melted and thoroughly mixed, then allowed to cool and solidify. According to the Germ. Pat. 151594, the solidification is brought about by mixing with 4—10 % melted soda soap which contains water glass.

Blücher.

According to the Germ. Pat. 176366 benzine is emulsified with slaked lime, and the emulsion solidified either by drying or by the addition of formaldehyde. The value of this method is questionable.

Benzine is a mixture of hydrocarbons, S. G. 0.640—0.70, B. P. between 60° and 120°. It is used for extracting, for removing grease &c., in laundry work, as well as for illuminating purposes, for driving motors &c.

Benzine-apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Bone grease Benzine Plant:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Benzinoform. See article on CARBON TETRACHLORIDE.

Tetra Isol (Water soluble Tetrachloride of carbon):

Louis Blumer, Zwickau Sa., Germany.

Benzine soap. In addition to other processes that of the Hung. Pat. 31885 (1904) seems to be of importance. The main features of the process are a) that 60 pts of palm nut oil are heated to such a temperature that the 8 pts of added resin are melted; b) that 30 pts NaOH 38° Bé. and 2 pts commercial benzine are mixed and stirred with the above mixture until the right consistency is obtained.

Benzine soap is used for cleaning and washing clothes, &c.

Benzine soap, solid, for chemical washing:

Louis Blumer, Zwickau Sa., Germany.

Benzoic acid $C_6H_5 \cdot COOH$. Formerly obtained from gum benzoin by sublimation or in the wet way by boiling with lime, and for medicinal purposes this method of preparation from the gum is still in vogue.

Another starting point for the manufacture, was and to a certain extent still is, the hippuric acid present in the urine of herbivorous animals. This after standing a few days, decomposes with formation of glycocholl and benzoic acid. By treating with milk of lime, calcium benzoate is formed and this is then decomposed by evaporating with HCl.

The largest amount of benzoic acid is however obtained by chlorinating toluene. The chlorine is introduced into the side group, thus forming benzal chloride, or more recently, benzotrichloride. From the latter the benzoic acid was at first obtained by treating with milk of lime under pressure, $2 C_6H_5 \cdot CCl_3 + 4 Ca(OH)_2 = (C_6H_5 \cdot CO_2)_2Ca + 3 CaCl_2 + 4 H_2O$. The benzotrichloride is however now converted into benzoic acid by oxidation with HNO_3 , this reaction being performed in boilers provided with stirring apparatus. HCl is liberated in this process, and the benzoic acid is purified by recrystallization or by distillation *in vacuo*. In the same way it is obtained from phthalic acid and from phthalimide. The by-products in the manufacture of benzaldehyde are also used for the preparation of benzoic acid.

The Germ. Pat. 109122 starts from a certain fraction of coal tar which smells of benzonitrile $C_6H_5 \cdot CN$, and saponifies this to benzoic acid.

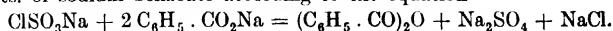
ULLMANN and UZBACHIAN's process in which toluene is directly oxidized with $KMnO_4$, has become very important. The yield of benzoic acid amounts to 90 % and the acid thus obtained is free from chlorine which makes it valuable for medicinal purposes.

Recently a further process (protected by numerous Germ. Pat. 136410, 138790, 139956 and 140999) has been discovered which aims at the simultaneous preparation of benzoic acid and phthalic acid. It was found that naphthols and other substitution products of naphthalene (nitronaphthalene, naphthylamine, naphthalenesulphonic acids &c.) could be converted into a mixture of phthalic acid and benzoic acid by heating with fused alkalis or

alkali lyes and such oxidizing agents as Fe_2O_3 , CuO , MnO_2 &c. The phthalic acid can be separated from the benzoic acid by distillation.

Finally we may mention that a method has been discovered for separating benzonitrile $\text{C}_6\text{H}_5 \cdot \text{CN}$ from the middle oils of the coal-tar distillation. The benzonitrile is then converted by saponification into a very pure benzoic acid.

Colourless thin plates, readily soluble in ether and alcohol, sparingly soluble in cold but more readily in hot H_2O . M. P. 120° , B. P. 250° . Sublimes between $100-120^\circ$. Its salts (benzoates) are almost soluble in H_2O . Benzoic acid is used medicinally, for the preparation of blue dyes in calicoprinting, &c. Benzoic anhydride $(\text{C}_6\text{H}_5 \cdot \text{CO})_2\text{O}$ is obtained according to the Germ. Pat. 146690 by heating 180 pts of the sodium salt of chlorosulphonic acid with 300 pts. of sodium benzoate according to the equation



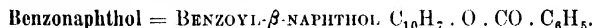
Benzoic anhydride may be also prepared by the action of sulphurylchloride or mixtures of Cl and SO_2 on benzoates. The Germ. Pat. 161882 aims at perfecting this well-known process.

Ethyl benzoate as well as methyl benzoate (NIOBE OIL) are colourless pleasant smelling liquids which are used as fruit essences and in perfumery.

The amidobenzoic acids as well as the nitrobenzoic acids find technical use (comp. art. on ANTHRANILIC ACID). With regard to amidobenzoicethyl ester see article on ANAESTHESIN.

Benzoïn gum. A pleasant smelling gum obtained from the STYRAX BENZOIN a native of Further India and Sumatra. All kinds (Sumatra benzoin, Siam benzoin, and Penang benzoin) consist of a brown matrix in which occur paler rounded nodules, the so-called "almonds". The greater the number of the almonds, the greater is the value of the sample. The most valuable kind is Siam benzoin which smells strongly of vanilla. Besides resins, volatile oils and esters, gum benzoin contains 12—24 % of benzoic acid. In Sumatra benzoin however the benzoic acid is almost entirely replaced by cinnamic acid.

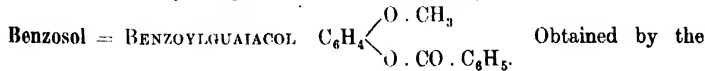
Gum benzoin is used in medicine (externally), in perfumery, and for the manufacture of benzoic acid.



It is obtained pure by the action of benzoyl chloride on β -sodiumnaphthol, and recrystallizing the product of the reaction from boiling alcohol. White, crystalline, odourless and tasteless powder, almost insoluble in H_2O , sparingly soluble in ether and alcohol, more readily in chloroform and hot alcohol. M. P. 107° . It is prescribed internally for abdominal diseases (diarrhoea-typhoid).

Benzophenone see KETONES.

Benzosalin (METHYLBENZOYL SALICYLATE) $\text{C}_6\text{H}_4(\text{COO} \cdot \text{CH}_3)(\text{O} \cdot \text{CO} \cdot \text{C}_6\text{H}_5)$. A white crystalline powder having a faint aromatic smell and taste, almost insoluble in water, soluble with difficulty in alcohol, easily in ether and chloroform. M. P. $84-85^\circ$. Passes through the stomach in an unaltered form and is decomposed only in the intestine. It is prescribed in doses of 2.0 to 5.0 grammes daily for gout, rheumatism, neuralgia, &c.



action of benzoylchloride on sodium guaiacol.

It combines therapeutically the action of guaiacol and benzoic acid and is specially prescribed in intestinal tuberculosis and in Diabetes mellitus. It forms white tasteless odourless crystals scarcely soluble in water and ether, readily in hot alcohol. M. P. $60-61^\circ$.

Benzotrichloride $C_6H_5 \cdot CCl_3$. Obtained by the action of chlorine on boiling toluene, while at the same time benzylchloride, benzalchloride and other chlorine substitution products are formed. The crude product is rectified *in vacuo*.

Pure benzotrichloride forms a colourless liquid, S. G. 1.38 (at 14°). B. P. 213°—214°. On being heated with H_2O to 140° it decomposes readily into HCl and benzoic acid. It is used in the manufacture of tar dyes (sometimes of benzoic acid).

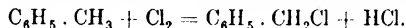
Benzoyl chloride (BENZOIC ACID CHLORIDE) $C_6H_5 \cdot COCl$. It is obtained commercially by the distillation of benzoic acid with PCl_5 . According to the Germ. Pat. 146690 it is obtained by the action of 2 mol. sodium chlorosulphonate on 1 mol. sodium benzoate. It forms a colourless, oily liquid of pungent smell S. G. 1.2324 (at 0°); B. P. 198.3°. It is decomposed by water with formation of HCl and benzoic acid. It is used in the manufacture of benzaldehyde and tar dyes.

Nitrobenzoylchloride finds some technical use.

Benzyl acetate $CH_3 \cdot COO \cdot CH_2 \cdot C_6H_5$. Obtained by the action of sodium acetate on benzyl alcohol in presence of conc. H_2SO_4 . Liquid, S. G. 1.069 B. P. 215—216°.

Benzyl alcohol see under BENZENE, BENZOYL, and BENZYL COMPOUNDS.

Benzyl chloride $C_6H_5 \cdot CH_2Cl$. Obtained by the action of chlorine on boiling toluene; only so much chlorine as is required by the following equation is used, otherwise benzalchloride and benzotrichloride are formed



Commercially the toluene is placed in an acid proof earthenware vessel and heated to boiling point by means of a steam spiral (of lead), while the exact amount of chlorine required is passed over its surface. The resulting benzylchloride is washed with a little water and rectified from enamelled distilling flasks.

WOHL's process (Germ. Pat. 139552) is perhaps destined to become important. According to this benzylchloride is obtained by allowing sulphuryl chloride to act in the dark, on an excess of toluene. The mixture is heated but its temp. kept below 130°; a reflux condenser condenses the escaping vapour. This method gives excellent results.

Benzylchloride forms in the pure state a colourless liquid of pungent smell S. G. 1.107 (at 140°) B. P. 176°. It is used for the preparation of different dyes; o- and p-nitrobenzylchloride also find employment in the manufacture of dyes. The former is obtained from o-nitrotoluene and chlorine at 150°—200°, while the p-compound is prepared by dissolving benzylchloride in fuming HNO_3 at a very low temperature.

Bergamot oil. An essential oil obtained from the fruit of *Citrus Bergamia* *Risso*. It is a mobile, greenish-yellow oil with a fine smell and a bitter aromatic taste. S. G. (at 15°) 0.882—0.886. B. P. 165°—190° Iodine number 248—284; potash absorption. 8.78—11.43%; $[\alpha]_D = +8^\circ - -20^\circ$. Soluble in KOH (distinction from lemon-peel and orange-peel oils. It contains the terpene limonene, the aliphatic alcohol linalool, and linalyl acetate (38 %).

Berlin blue see IRON COLOURS.

Beryllium and beryllium compounds.

Beryllium Be. At. Wt. = 9.05. One of the light metals belonging to the magnesium group; resembles aluminium in many respects. It is usually obtained by the action of Na on potassium beryllium fluoride. It forms a

white, hexagonal crystalline metal, which has a melting point near that of silver. S. G. 1.64. It is readily dissolved by lyes and dilute acids.

BERYLLIUM OXIDE (GLUCINA) BeO . Obtained by fusing beryl — a double silicate of beryllium and aluminium. White amorphous infusible powder. Of the salts, the following may be mentioned, beryllium chloride BeCl_2 , beryllium carbonate BeCO_3 , beryllium nitrate $\text{Be}(\text{NO}_3)_2$ and beryllium sulphate BeSO_4 . These are all soluble in H_2O .

According to the Germ. Pat. 155466, beryllium compounds may be prepared by treating the minerals with acetic acid. Of the acetates thus obtained, only one — that of Be — is converted, on treating again with glacial acetic acid, into a form which is soluble in CHCl_3 . Thus the Be may be separated from the other constituents by extraction with chloroform.

Beta-Eucaine see EUCAINE.

Beta sulphopyrin. A compound of sulphanilic acid with antipyrine (not identical with SULPHOPYRIN). It is an acid tasting powder soluble in hot water, prescribed in cases of influenza, colds and especially for iodine poisoning.

Betol = SALICYLIC ACID- β -NAPHTHYL ESTER. $\text{C}_7\text{H}_5\text{O}_3 \cdot \text{C}_{10}\text{H}_7$. Obtained by the action of POCl_3 on a mixture of sodium- β -naphthol and sodium salicylate.

It forms a white, odourless, tasteless, crystalline powder, insoluble in H_2O , sparingly soluble in cold alcohol, readily soluble in boiling alcohol, ether and benzene.

It is taken internally as an antiseptic for catarrh of the bladder, rheumatism, &c.

Bichromates see CHROMIUM COMPOUNDS, also the respect. metallic compounds.

Binitrobenzene see DINITROBENZENE.

Binitrotoluene see DINITROTOLUENE.

Bioferrin. A liquid haemoglobin preparation, obtained from the cold fresh blood of oxen after removing the fibrin by treating with ether and separating the constituents which are soluble in the ether. The serum, which contains the haemoglobin, is freed from the last traces of ether by passing in a stream of sterilised air, and then 20% glycerine and 4% aromatic tincture are added.

Blood red, pleasant tasting liquid of S. G. 1.081 (at 15°). It is specially prescribed for chlorosis, and for patients in a weak state of health; infants are given 5–10 grm, children 10–20 grm, adults 20–40 grm, either just before or during meals.

Bioson. A nutritious preparation containing iron, albuminoids and lecithin is brought into commerce under this name. According to the formula the composition is as follows, albuminoids 80, iron 0.24, lecithin 1.27, cocoa 15, salts 3%. The analytical results obtained by SORMANN differ somewhat from this, but not to any great extent.

Fine greyish-brown powder with a distinct smell of cocoa and a not unpleasant somewhat salty taste. It is almost entirely soluble in H_2O especially on being heated.

Bismon. Colloidal bismuth oxide; it is a remarkable form of bismuth-metahydroxide, and is formed by the action of sodium lysalbinat and protalbinat (see art. PROTALBINIC ACID) on bismuth compounds.

Bismon is soluble in cold and in hot H_2O . It is a good mild intestinal astringent, and is prescribed for different diseases of the intestines. Usually 5 cm of a 10% solution (0.5 grm Bismon per dose) are given 3–4 times daily, either alone or in liquid foods.

Bismuth. Bi At. Wt. 208.9. Bismuth occurs usually in the pure state; however bismuth glance Bi_2S_3 , and bismuth ochre Bi_2O_3 , are of importance

in the metallurgy of this metal, which belongs to the P, As, Sb group of elements.

The ores are usually first roasted and then smelted with coal, iron and slag. The charcoal acts as a reducing agent, the iron combines with the S present, while the slag absorbs the SiO_2 . Thus directly underneath the slag, and solidifying with the latter, a layer is obtained which contains Pb, Ag, Ni, Co, and Fe with S and As, while the heavy layer of Bi remains liquid for a longer time at the bottom and can be run off. The crude bismuth undergoes a preliminary purification by carefully melting it on an inclined iron plate, whereby it flows away from the metallic impurities. It is further refined either by oxidizing the impurities by melting with KNO_3 or with Na_2CO_3 and KClO_3 , or by dissolving the metal in HNO_3 , precipitating the $\text{BiO}(\text{NO}_3)$ with H_2O , and then reducing the latter with C.

By extracting Pb and Ag ores which contain Bi, a lead is obtained which contains a large amount of Bi, from which bismuth chloride can be dissolved by digestion with HCl; by means of H_2O the basic bismuth chloride is precipitated. This requires to be repeatedly dissolved and precipitated in order to obtain a pure compound. Finally after being washed it is dried and melted with charcoal, soda and glass in iron crucibles.

Very glistening, reddish white, brittle metal which cracks on bending and crystallizes in almost cubical rhombohedra. S. G. 9.8. Hardness 2.5. M. P. 268° . B. P. about 1600° . Moist air tarnishes its surface. It is a poor conductor of heat. The chloride and nitrate of Bi are decomposed by H_2O with the precipitation of basic salts.

Bismuth is practically only used in the form of alloys and compounds

Bismuth:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Bismuth alloys. The alloys of Bi are characterised by a very low melting point, and are used for clichés, wood cuts, and stereotype plates, further for soldering easily fusible alloys, for making metal baths for the hardening of steel. Finally, safety plugs for boilers are made of readily fusible Bi-alloys.

Known bismuth alloys are

WOOD'S METAL:— 15 Bi, 8 Pb, 4 Sn, 3 Cd. (M. P. 68° .)

ROSE'S METAL:— 8 Bi, 8 Pb, 3 Sn. (M. P. 79° .)

LIPOWITZ'S ALLOY:— 15 Bi, 8 Pb, 8 Sn, 3 Cd, (M. P. 70°); the alloy becomes soft below 60° , and is specially suitable for the preparation of fine casts of objects which cannot stand a high temperature.

NEWTON'S METAL:— 8 Bi, 5 Pb, 3 Sn. (M. P. 94.5° .)

The following alloys may be used for safety plugs for boilers.

	Bi	Pb	Zn	M. P. 0°C	Pressure in atmosph.		Bi	Pb	Zn	M. P. 0°C	Pressure in atmosph.
I	8	5	3	100	1	VII	8	16	12	146	4
II	8	8	4	113.3	1.5	VIII	8	22	24	154	5
III	8	8	3	123	2	IX	8	32	36	160	6
IV	8	10	8	130	2.5	X	8	32	28	166	7
V	8	12	8	132	3	XI	8	30	24	172	8
VI	8	16	14	143	3.5						

Bismuth colours. Only, basic bismuth nitrate $\text{BiO}(\text{NO}_3)$ is used as a paint, not however as a painter's colour, but as a cosmetic, and has the names, bismuth white, paint white, pearl white, and Spanish white. It is prepared by dissolving Bi in excess of fuming HNO_3 and pouring the solution into water, when the basic nitrate is precipitated. It is a heavy white powder, which turns

yellow in the air and is very sensitive to the action of H_2S . On this account and also because of the high price it is becoming more and more replaced by zinc white. (See under ZINC COLOURS.)

Bismuth compounds. The most important are bismuth chloride, bismuth nitrate, and bismuth oxide.

1. **BISMUTH CHLORIDE (BISMUTH TRICHLORIDE)** BiCl_3 . Obtained by heating Bi in a current of chlorine, or by dissolving Bi in aqua regia or Bi_2O_3 in HCl . Crystalline mass M. P. 227° ; B. P. 447° . If concentrated solutions are diluted with much water, a beautiful white precipitate of bismuth oxychloride BiOCl (soluble in acids) is obtained. The latter compound is used for the same purposes as the bismuth subnitrate. (See under BISMUTH PAINTS.)

2. **BISMUTH NITRATE, BASIC (BISMUTH SUBNITRATE)** $\text{BiO}(\text{NO}_3)$. Preparation see under BISMUTH COLOURS. It is principally used in medicine and for porcelain lustre paints as well as a cosmetic.

3. **BISMUTH OXIDE (BISMUTH TRIOXIDE)** Bi_2O_3 or Bi_4O_8 . It occurs naturally as bismuth ochre, is artificially prepared by heating the nitrate, carbonate or hydroxide as well as by heating the metal for a long time in the air. Yellow powder, insoluble in H_2O (S. G. 8.2), melts at a red heat to a brown liquid and solidifies to a yellow crystalline mass. It is used in glass manufacture. If the PbO in flint glass be replaced by Bi_2O_3 , a very highly refracting glass is obtained.

4. **BISMUTH HYDROXIDE** $\text{BiO} \cdot \text{OH}$. Is formed as a white precipitate on adding the nitrate to potassium hydroxide, and can be dried at 100° .

Bismuthose. Bismuth iron compound which contains 21.5—22 % Bi. It is a very fine, odourless and tasteless powder, which swells up in H_2O . It is a well known intestinal astringent, and is prescribed for various intestinal sicknesses.

Bisulphate (SODIUM BISULPHATE). For preparation and properties see No. 35 b under SODIUM COMPOUNDS.

Bisulphite of Lime:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London S.E.

Bixine (ORLEAN RED) see VEGETABLE DYES.

Blackening. Mixtures of very different composition, mostly bone black, wood oil, hog's fat, syrup, and sulphuric acid; or also without sulphuric acid but with turpentine shellac &c. Coloured polishes contain various other dyes instead of bone black.

Blackening:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Blanc.

B. de baleine = spermaceti.

B. de fard

B. d'Espagne } = bismuth subnitrate.

B. de Troyes } = white chalk.

B. de Meudon }

B. de neige = zinc oxide.

B. fixe = baryta white.

Blasting gelatine see DYNAMITE.

Blasting oil see NITROGLYCERINE.

Bleaching.

A. CHEMICALS for BLEACHING.

1. BLEACHING POWDER (see this). The solid bleaching powder is mixed with water but the residue of Ca(OH)_2 always retains some of the bleaching agent. On this account the liquid "chloride of calcium" is often prepared on the spot by passing Cl into thin milk of lime.

The efficiency of "chloride of lime" for bleaching is increased by the addition of acetic acid. Only a small amount is necessary as it is always being regenerated from the Ca salt formed.

2. SODIUM HYPOCHLORITE (EAU DE LABARRAQUE) NaOCl . Obtained by passing Cl into a solution of soda, or by the interaction of soda and bleaching powder. Of late years it has been manufactured by the electrolysis of NaCl solution (compare CHLORINE ALKALI PROCESS, ELECTROLYTIC). According to the Germ. Pat. 145745 bleaching powder and cryst. sodium sulphate in the dry state, are pressed together: double decomposition takes place, and sodium hypochlorite and hydrated calcium sulphate are formed, which keeps the mass in a solid state.

EAU DE JAVELLE. It is really a solution of potassium hypochlorite, obtained in the same way as NaClO . However, the solution of NaClO is usually termed EAU DE JAVELLE.

4. MAGNESIA BLEACHING LIQUID Mg(OCl)_2 . Is obtained by the action of bleaching powder on MgSO_4 . It is more readily decomposable than bleaching powder, and so bleaches more quickly.

5. ALUMINA BLEACHING LIQUID and

6. ZINC BLEACHING LIQUIDS are also hypochlorites prepared and used in a manner similar to the above.

7. HYDROGEN PEROXIDE (see this).

8. SODIUM PEROXIDE see No. 27 c under SODIUM COMPOUNDS.

9. OZONE O_3 (see this). Recently this has been very largely used for bleaching. With SIEMENS and HALSKE'S apparatus, 20 grm ozone are produced per horse-power hour. With this amount 50 kg linen yarn can be bleached to the same extent as with 3-days' bleaching on grass in good weather. 40 kg of potato starch may be bleached perfectly white with this amount of ozone.

The ozone bleaching is not cheaper than bleaching on grass but the amount of time saved is considerable (under unfavourable conditions 14 days bleaching on grass correspond to 1 day of ozone bleaching).

10. ELECTROLYTIC BLEACHING. By the electrolytic decomposition of alkali chlorides, large amounts of Cl are formed which, under suitable conditions, can react with the alkali hydroxide simultaneously obtained to form hypochlorites. KELLNER'S process seems to be very advantageous. In this a NaCl solution is allowed to flow through a special apparatus. This apparatus consists of a box of hard rubber in which a large number of electrodes "in series" are placed. The electrodes consist of hard rubber plates which are studded with platinum points like a brush. When the NaCl solution flows through, sodium hypochlorite is formed, the rate of circulation being so regulated that the percentage of active Cl in the solution increases 0.05 % every time the solution passes through. The solution is allowed to accumulate until it contains about 1 % of active Cl, and is then used for bleaching in the textile industry, and in paper and cellulose manufacture.

The KELLNER apparatus designed by SIEMENS and HALSKE has been recently modified and greatly improved. It is now constructed in different sizes and consists of the real electrolytic apparatus and the circulating arrangement. The electrolytic apparatus is a cell lined with glass and earthenware, provided with exit and entrance pipes, into which the electrodes are inserted. The electrodes are now made of platinum-iridium wires, so that they cannot be destroyed by chemical agents. The circulating arrangement consists of a

collecting vessel with a cooling spiral for the salt solution which is to be decomposed. The solution is continually passed into the electrolytic apparatus by means of a centrifugal pump of lead and by means of suitable pipe connections; the circulation is completed by the overflow into the collecting vessel. The cooling spiral is connected with a water supply and thus the salt solution is kept at a temp. of 20° — 25° during the passage through the collecting vessel. In this way the formation of NaClO_3 , which is useless for bleaching purposes is prevented.

The amount of active chlorine formed increases with the strength of the current, the concentration of the salt solution, and the duration of the electrolysis. By means of special improvements it is possible to produce solutions containing 5 % active chlorine although this formerly appeared to be quite impossible. The production of chlorine according to this process is very cheap.

Further the process of KRON seems to work very well. By the electrolysis of a NaCl solution a bleaching liquid called "power-chlorine" by the discoverer is prepared. The electrodes of the apparatus consists of an alloy of platinum iridium and are on this account very durable.

Summarising, we may say that the most important apparatus for electrolytic bleaching are those of KELLNER, HAAS-OETTEL, SCHUCKERT, and SCHOOP. The apparatus of KELLNER and SCHOOP has platinum electrodes, that of HAAS and OETTEL carbon electrodes, that of SCHUCKERT carbon for the negative, platinum for the positive electrode.

B. METHODS of BLEACHING in the TEXTILE INDUSTRY.

I. COTTON BLEACHING.

a) SINGING. Removal of the fibres on the fabric which are injurious in printing. This is carried out with advantage by means of the gas-singeing machine.

b) WASHING the cloth, after it has been twisted into rope form, in special washing machines.

c) SOAKING with lime. Saponification of the fatty and resinous impurities in the fabric by means of lime water. The cloths are brought into a special machine (lime-, chlorine-, and acid machine), drawn through thick milk of lime, and then boiled in the high pressure boiler.

d) ACIDIFICATION. By treating with hydrochloric acid the lime soaps are decomposed, gums and fatty acids are precipitated, while CaCl_2 goes into solution.

e) SOAKING with lyes or resin soaps. By boiling the cloths with dilute NaOH or resin soaps the fatty substances still present are removed.

f) CHLORINATION see above.

g) ACIDIFICATION. The addition of HCl decomposes the remains of the bleaching powder, and removes the last traces of Fe and Ca .

h) TREATMENT with antichlors (see this) and then careful washing.

II. LINEN BLEACHING. The linen goods are first either boiled or soaked with soda, then chlorinated, acidulated, boiled, then again chlorinated, acidulated and this process repeated several times. The fibres are afterwards exposed to air bleaching (or to ozone).

III. HEMP BLEACHING. Is only seldom practised, and then similarly to linen bleaching.

IV. JUTE BLEACHING. First soaking in weak water glass solution, treatment with EAU DE JAVELLE, and acids, then washing and drying. The treatment with KMnO_4 and then with aqueous SO_2 is less destructive.

V. WOOL BLEACHING.

a) WASHING. Repeated treatment with lukewarm water.

b) **REMOVAL OF GREASE.** Is carried out in special wool washing machines, with the addition of soda, soap, urine, &c.

c) **BLEACHING.** Is only carried out when the wool is not to be dyed or only to be dyed in light shades. As "chloride of lime" does not bleach wool but merely turns it yellow, and alkalis destroy the fibres, either sulphurous acid or better hydrogen peroxide (or at times KMnO_4) must be used.

VI. SILK BLEACHING.

a) **ELIMINATION OF THE BAST.** Removal of the gum by washing the strands in neutral soap solution.

b) After the silk glue has been removed, the strands are washed in dilute soda solution, boiled in soap solution, again washed in soda, and then bleached with gaseous sulphurous acid or hydrogen peroxide.

Bleaching powder is obtained by the action of chlorine on slaked lime. The lime must be as pure as possible, very carefully burnt and only slaked enough to give a dry powder. The Ca(OH)_2 is placed in chambers of wood, sandstone or of slates; of late also in larger chambers of lead. The measurements of the leaden chambers are 30 m. in length, 10 m in breadth and 2 m in height. In the chambers the Ca(OH)_2 is placed on trays in the thinnest possible layers one over the other. The chlorine is then conducted in through the roof. Some new arrangements have lately been invented for continuous working. The Cl can be obtained in different ways, among others by the electrolytic process. Compare **CHLORINE**. Several patents have also been taken out for direct electro-chemical methods of obtaining bleaching powder.

It is not yet quite clear what is the true constitution of chloride of lime. At any rate it is not pure calcium hypochloride Ca(OCl)_2 . The formula $\text{CaO} \cdot \text{CaCl} \cdot \text{OCl}$ is the best and most probable one yet suggested. Chloride of lime is used in bleaching works, compare **BLEACHING**, it is also employed as a disinfecting agent as well as for oxidation, further for obtaining chloroform, for purifying methylated spirit and so on. The value of the chloride of lime is determined either by weight (percentage of Cl) or by Gay Lussac degrees, which register how many litres of Cl are obtained from 1 kg of the bleaching powder.

According to Germ. Pat. 145745 a mixture of chloride of lime and crystallized Na_2SO_4 is pressed together in a dry condition; by double decomposition sodium hypochlorite and hydrated CaSO_4 are formed. The material is employed for bleaching.

TEST. The technical analysis comprises exclusively the determination of the quantity of available chlorine, that is, of the quantity of the compound CaOCl_2 . The determination of contents is best carried out by titration with an $\frac{1}{10}$ N. alkaline solution of sodium arsenite according to the method of **PENOT-LUNGE**. 7.1g of the well mixed sample of chloride of lime is weighed off and mixed in a porcelain mortar with a little H_2O to a smooth fine paste; it is then diluted with more H_2O , poured into a litre flask and diluted up to the mark and the required amount measured out with a pipette after vigorous shaking of the flask 50 cc = 0.355 g chloride of lime. The arsenite solution is run in with constant shaking until the desired degree is approached. After this a drop of the mixture is put on a filter paper, previously moistened with a little KI. starch solution. The filtration is continued until only a very slight, or until no blue spot appears on the test paper. The arsenite solution is prepared by weighing out 4.950 g of pure arsenious oxide, boiling with 10 g NaHCO_3 and 200 cc H_2O until completely dissolved. 10 g NaHCO_3 are then added and the solution after cooling is diluted to 1 litre. 1 cc = 1 % available chlorine.

Blood charcoal. Obtained by evaporating blood with 15–20 % potash, carbonising, boiling with HCl (to remove K_2CO_3), washing with H_2O , and

heating in absence of air. It is largely used on account of its extraordinary capacity for decolorizing substances. A similar preparation is made from plants and is termed vegetable blood charcoal.

Blood meal see MANURES, ARTIFICIAL.

Blood stone. Special variety of red iron ore Fe_2O_3 , reddish brown, of fibrous structure and silky appearance. Is used for polishing either as powder or in pieces, and also finds employment as a red paint.

Blue wood see VEGETABLE DYES.

Blue gas see OILGAS.

Blue see "WASHING BLUE".

Bobbinit see SAFETY EXPLOSIVES.

Boiling points.

	B. P. °C		B. P. °C
Acetanilide	+ 295	Glycerine	+ 290
Acetic acid (glacial)	+ 119	Hydrocyanic acid	+ 26.5
Acetic anhydride	+ 138	Hydrofluoric acid	+ 19.4
Acetone	+ 56.3	Hydrogen	- 243
Air	- 191	Iodine	+ 180
Alcohol (ethyl alcohol)	+ 78.4	Lead	+ 1510
Aldehyde (Acetaldehyde)	+ 20.8	Linseed oil	- 316
Ammonia	- 34	Mercury	+ 357.25
Amyl alcohol	+ 129—131	Methyl alcohol	+ 66—67
Aniline	+ 184.1	Methyl salicylate	+ 223
Anthracene	+ 351	Naphthalene	+ 217.9
Anthraquinone	+ 373	α Naphthol	+ 278—280
Benzaldehyde	+ 179.1	β Naphthol	+ 285—286
Benzene	+ 80.5	Nitrogen	- 194.4
Benzoic acid	+ 249.2	Oxygen	- 182.7
Benzophenone	305.8	Paraffin	+ 300
Bromine	+ 59	Phenol	+ 180
Cadmium	+ 860	Phosphorus	+ 290
Camphor	+ 205	Potassium	+ 720
Carbon dioxide	+ 79	Sodium	+ 742
Carbon disulphide	+ 46	Stannous chloride	+ 606
Carbon monoxide	- 190	Sulphide of phosphorus	+ 518
Carbon tetrachloride	+ 77	Sulphur	+ 448.4
Chlorine	- 33.5	Sulphurous acid	- 8
Chloroform	+ 61	Toluene	+ 111
Chrysene	+ 448	Triphenylmethane	+ 356.2
Cyanogen gas	- 21	Turpentine oil	+ 157
Diphenylamine	+ 310	Water dist.	+ 100
Ether	+ 35	Zinc	+ 730
Formaldehyde	- 21	Zinc chloride	+ 730
Formic acid	+ 99		

Boilers.

Copperboilers:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Boilers of various metals:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Heymann, Gaismann & Co., Bradford.

Earthenware-boilers:

Westdeutsche Steinzeug-Chamotte- und Dinas-Werke G. m. b. H., Euskirchen, Rheinland Germany (see front part adv.).

Boiling apparatus:

Friedrich Heckmann, Berlin SO. 18, Brückenstr. 6b (see advts.).

Boiling apparatus of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Bone ash (BONE EARTH). Obtained by heating bones in the air. The largest amount is obtained in South America. In the manufacture of extract of meat the bones of the slaughtered animals are used as firing material; the bones are left behind in the form of bone ash. When ground it forms a white powder which contains 67—85 % basic calcium phosphate, 2—3 % magnesium phosphate, 3—10 % calcium carbonate, a little caustic lime, and on an average 4 % calcium fluoride.

Bone ash is used for the preparation of phosphorus and phosphoric acid, enamels (glazes), and milk glass, for making muffles and cupels; it is also used as cleaning and polishing material. Further it is used as a manure, and also for the manufacture of superphosphates.

Bone black see **IVORY BLACK**.

Bone Ash:

Johnson's, Cross St., Finsbury, London.

Bone charcoal (ANIMAL CHARCOAL). Obtained by the complete carbonisation of broken or chopped up bones in the absence of air. The bones must be dense, hard and fresh; before carbonising the fat must be removed by extraction. The carbonisation is carried out either intermittently in well closed iron pots, or uninterruptedly in iron cylinders. By the latter process the products of the dry distillation may also be obtained. It forms a hard, very porous, dull mass, of different sized grains; when of good quality it is dark black; alkaline liquids must not be coloured when boiled with the charcoal. It contains approx. 10% carbon and 90% mineral substances, principally calcium phosphate.

On account of its property of absorbing dyes and other organic substances as well as salts, it is very largely used. Formerly it was indispensable in sugar refining (see this) and is still used for this purpose. Continual use reduces its absorptive power and it must be then made effective again by removing the absorbed substances. To do this it is washed, and the absorbed line removed with HCl, the gypsum by boiling with Na₂CO₃ solution and afterwards treating with HCl. The organic stuffs are removed by a fermenting and putrefying process, after which the bone charcoal is heated. It is more advantageous to boil the charcoal with NaOH than to ferment it. It is afterwards washed, steamed, dried, and burned. It must not be too strongly heated as otherwise the porosity is diminished.

Comp. also the article on **IVORY BLACK**.

Bone crushers.**Bone Crushers:**

Max Friedrich & Co., Leipzig-Plagwitz 17.

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Bone fat. It is obtained almost exclusively from the marrow in hollow bones by three different methods, namely, either by boiling with water, or by treating with high pressure steam, or by extracting with a suitable solvent-usually petroleum, benzine or carbon disulphide. In all three methods the bones must be first broken up in a bone breaker. The yield, best in quality but least in quantity, is obtained by boiling. The largest yield is obtained by extraction, but the product (extraction fat) is the least valued on account of its bad odour. One advantage of the extraction method over the other two is that the bones suffer no loss of glue.

The fat obtained by boiling is slightly brown; it is easier to bleach and render odourless than the more impure dark brown or black coloured fat prepared by extraction. For refining bone fat the same methods are usually employed as for refining tallow (see this). From the fatty or oily mass obtained by refining a more solid fat and an oil, bone oil (see this) are obtained, either by pressing or freezing.

Either chromic acid or air may be used for bleaching. In the first case it must be boiled with salt solution of 14—15 degrees before bleaching, and in the second case the fat must be placed in layers frequently turned over, and after 2—3 weeks melted with salt water.

Bone meal see MANURES, ARTIFICIAL.

Bone oil. Liquid part of the bone fat (see this), obtained from the latter by pressing or freezing after refining. Bone oil is very stable in the cold, and does not become rancid.

Bone polishing drums:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Bone phosphate see SUPERPHOSPHATE.

Bone size see GLUE.

Boracite (STASSFURTITE). Is classed among the Abram salts (see this) and is a double salt of magnesium borate and magnesium chloride of the formula $2 \text{Mg}_3\text{B}_6\text{O}_{15} + \text{MgCl}_2$. However almost all the Stassfurt minerals which contain boron are brought into commerce under the name of boracite after they have been roughly purified.

Boric acid is then manufactured from them.

Boral. It is obtained according to the Germ. Pat. 77315 by heating aluminium borate and tartaric acid in aqueous solution, until all is dissolved, filtering and evaporating the filtrate. Colourless, crystalline salt, readily soluble in H_2O . It is prescribed in cases of skin disease and inflammations of the ear on account of its antiseptic qualities.

Borax (SODIUM BIBORATE) $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$. Occurs naturally as a mineral (TINCAL), which occurs in some of the lakes in Thibet, India, and California. The purification is carried out by treating the crude borax with milk of lime. After thoroughly mixing, it is dissolved in boiling H_2O and allowed to settle. After the fatty substances have thus been converted into insoluble calcium soaps, the clear solution is drawn off, and freed from the last traces of the calcium soap with calcium chloride. Finally the clear borax solution thus obtained is evaporated and allowed to cool in crystallizing dishes, in which the borax separates out in crystals.

The largest amount of borax is obtained artificially. Two kinds must be distinguished, the common (prismatic) borax, and the octahedral borax (jeweller's borax). The latter contains only 5 mol. H_2O , and crystallizes out of strong solutions (30° Bé.) of common borax between 55° and 80°.

The common prismatic borax is obtained by the action of soda solutions on boric acid, in large quantities from calcium borate (mineral COLEMANITE from California) by boiling with soda; and partly from boracite. In the latter case the boric acid is first prepared (see under BORON COMPOUNDS) and from this the borax is obtained by the action of soda. According to the Russ. Priv. 5938 (1901) borax is produced by decomposing mineral borates with ammonium carbonate (or ammonium sulphite). The ammonium borate formed is converted into borax by double decomposition with NaCl or NaNO_3 .

The octahedral borax $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5 \text{H}_2\text{O}$ is obtained under special conditions from the solution of the prismatic borax. Strength of solution 30° Bé. Tem-

perature of crystallization 59—76°. Common borax forms colourless, glistening columnar crystals, which become coated with a crust of the effloresced salt.

100 pts H_2O dissolve 4.6 pts prismatic borax at 10° C. and 120 pts at 90°.

The octahedral borax forms large, much harder crystals, which are more stable in the air, and more sparingly soluble in H_2O .

Borax:

Borax Consolidated Ltd., 16 Eastcheap, London E.C.

Borax glass.

Borax Consolidated Ltd., 16 Eastcheap, London E.C.

Boric acid (BORACIC ACID) H_3BO_3 . Occurs in volcanic districts, chiefly in Tuscany, partly in crystals, partly dissolved in hot springs, partly also in the hot vapours emitted in those districts. By conducting the vapours into water a 2 per cent solution of boric acid is obtained, from which the acid itself is prepared by evaporation.

Besides this, boric acid is artificially produced from numerous minerals, e. g. to a large extent from Stassfurtite. Stassfurtite is a double salt of magnesium borate and magnesium chloride; it is dissolved in slightly diluted HCl and the resulting mass treated with boiling water. At a temperature of about 100° the solution becomes clear and the fluid is then placed in crystallizing vessels. The resulting crude boric acid is purified by recrystallization. The initial crystallization takes place in wooden vats lined with lead, the recrystallization in earthenware pans. The production of boric acid from the mother-liquors, a process which till recently was not profitable, is now protected by the Germ. Pat. 136181. According to this patent it is possible to obtain the whole of the boric acid from the mother-liquors in a chemically pure state, without any evaporation, by adding liquids which cause the separation of the acid but do not mix with the liquor; such agents are ether, acetic acid and chloroform.

Other boron minerals are utilized in the production of boric acid, the mineral being decomposed with acid.

Pure boric acid crystallizes in oily-looking, shining colourless scales of the triclinic system. At 15° it dissolves in 30 parts of water, in three parts at 100°. It is volatile in steam and dissolves readily in alcohol; at a temperature of 100° the ordinary boric acid (ortho-boric acid) $B(OH)_3$ is converted into meta-boric acid $BO \cdot OH$, and the latter is converted into pyroboric acid $H_2B_4O_7$, at a temperature of 140°. By heating, boron trioxide (boric anhydride) B_2O_3 is obtained, as a glassy substance. M. P. 180°.

Boric acid:

Borax Consolidated Ltd., 16 Eastcheap, London E.C.

Borneol (CAMPHOL; BORNEO CAMPHOR) $C_{10}H_{17} \cdot OH$. Derivative of the terpenes:—an alcohol of the camphane group. It occurs in three modifications, dextro rotatory, laevo rotatory and inactive. Borneol is a widely distributed kind of camphor, which occurs principally in Borneo and Sumatra in the old trunks of the *Dryobalanops camphora*, and is mechanically collected there. The “d” and “l” modification of borneol are formed artificially and simultaneously when common camphor is reduced with Na in alcoholic solution or in neutral solvents.

The methods, by which artificial borneol and camphor are manufactured from certain terpenes, especially oil of turpentine, appear to become more and more important. Thus the Pontchester Chemical Co. in New York manufactures borneol (and from this artificial camphor) by allowing oxalic acid to act on turpentine oil — which is free from camphor — and treating the mixture with CaO, when the borneol and camphor formed are distilled off. The compound pinyl formate decomposes on being heated into borneol and CO.

The Germ. Pat. 175097 and 178934 describe the preparation of borneol and isoborneol by heating substances such as turpentine which contain pinene or camphenes with monoxy aromatic acids e.g. salicylic acid. The ester so prepared is boiled with soda.

For further information on these methods of artificial preparation see article "CAMPHOR". When pure, it forms crystals which have an odour resembling that of camphor but with a smell of pepper and ambergris. M. P. 203—204°. B. P. 212°. $\alpha_D = +37^\circ$ — 38° .

Bornyl acetate (artificial pine-needle oil). Prepared from borneol by the action of formic acid and acetic anhydride.

Bornylal. Trade name for bornyl iso valerianate $C_{10}H_{17}O \cdot C_5H_9O$. Clear liquid smelling and tasting faintly of valerian B. P. 255°; used medicinally.

Boroglycerine $C_3H_5BO_3$. Prepared by heating 62 parts of boric acid and 104 parts of glycerine to 150°. Pale yellow transparent mass with vitreous fracture, soluble in water and alcohol. Used as an antiseptic.

Borol. Fused mixture of boric acid and sodium bisulphate is used as an antiseptic.

Boron B. A. W. 10.94. Obtained from boric anhydride by fusion with metallic Na in the absence of air. Recently it has been obtained by MOISSAN in the electric furnace. According to the Germ. Pat. 147871 boron is prepared in the crystalline form, with the help of Al, by igniting a mixture of aluminium powder, sulphur, and a boric oxide compound. The mixture starts to burn and melts to form a mass of aluminium sulphide, in which on cooling the crystals of boron are found embedded. They can be obtained by decomposing the Al_2S_3 with H_2O . According to the Amer. Pat. 785962, boron may be prepared by electrolysis the fused borates of electropositive metals, using a comparatively large current between a cathode and a carbon anode, which reduces the boric anhydride.

Amorphous boron is a chestnut-brown, non-fusible powder, S. G. 2.45, somewhat soluble in H_2O . It dissolves in melted Al and separates out again on cooling in crystals which resemble graphite. The crystals vary from transparent yellow to black with metallic lustre. The variety of crystalline boron of S. G. 2.68 almost exceeds the diamond in hardness. Commercially the element boron is very little used, but its compounds are of great importance.

Boron compounds. Borax, boric acid, and perborates are treated in separate articles. The other borates are to be found under the corresponding metallic compounds.

BORON CARBIDE see under CARBIDES.

Borovertin. Hexamethylenetetramine triborate $(CH_2)_6N_4 \cdot 3 HBO_2$. A colourless crystalline powder soluble in water, having a faint salty acid taste, containing 51.5 % hexamethylenetetramine and 48.5 % anhydrous metaboric acid, equal to 68.4 % of officinal boric acid. Used as a non-irritating antiseptic in urinary troubles.

Bottles.

E. Breffit & Co. Ltd., Castleford, Yorks.

Iron bottles:

Kleine, Neuschaefer & Co., Schwelm, Westf., Germany.

Boxes.

Boxes of Earthenware:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Brandol. 1 % aqueous solution of picric acid, containing also 0.4 % undissolved acid. Used for burns.

Brass see 'COPPER ALLOYS'.

Brass plating. For general information see under **ELECTRODEPOSITION**. The brass baths are combined copper-zinc baths; the following receipts may be recommended.

Brass bath 1. In this A stands for copper, zinc, and iron, B for iron goods.

Bath A contains 0.4 grm Cu and 2.3 grm Zn in 1 lit., bath B 1.9 grm Cu and 13.5 grm Zn in 1 lit.

	A	B
Copper vitriol, pure	16	75 gr
Zinc vitriol, pure	100	600 gr.
Potassium cyanide pure	160	1350 gr.
Distill. water	10	10 lit.

The CuSO_4 and ZnSO_4 are dissolved in 5 lit. H_2O on the one hand, and the KCN in H_2O on the other, and then the two solutions are mixed. As cyanogen gas is evolved by this process, it must be carried out either in the open, or in a draught chamber.

Brass bath 2. 150 grm CuSO_4 and 150 grm ZnSO_4 are dissolved together in 2 lit. H_2O and concentrated Na_2CO_3 solution is added as long as a precipitate is formed (about 400 grm crystal soda). The precipitate of zinc carbonate and copper carbonate is repeatedly washed, and then brought into a solution of 200 grm sodium bisulphite powder, 200 grm pure KCN, 200 grm cryst. soda, and 2 grm arsenious acid (arsenic sesquioxide) in 5 lit. H_2O ; after filtering, the solution is made up with water to 10 lit.

The anode is either a plate of brass, or plates of zinc and copper; the colour of the brass deposit may be varied within wide limits by dipping the plates unequally deep, or by using plates of different size.

The electrolysis is carried out in cold solution, at ordinary temperatures, with a current strength of 0.6—0.7 Amp., and 3—4 volts.

Sheet-brass:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Brass Plating:

Cannings, Great Hampton St., Birmingham.

Brass-Foundry:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Brassfoundry, Redbrassfoundry, Phosphorbronze and Metallfoundry of all kinds:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Bricks. A distinction is made between weather-proof and fire-proof bricks.

For fire-proof bricks difficultly fusible slate, which is poor in fluxes, is repeatedly burnt and then mixed with a fatty plastic clay. The fire-proof Dinas bricks (Flintshire stones) are formed by mixing pure quartz with milk of lime.

The raw material for the common bricks is calcareous clay (clay marl) such as is found especially in North Germany in very large deposits. It contains CaCO_3 not only evenly distributed, but also in larger pieces (kidneys), and also iron ochre, sand, felspars, &c. If the clays are too greasy they are mixed with sand.

The clay is loosened by exposing it to the air for a long time, and then washed in order to free it from coarser impurities. The clay is then worked up in vertical or horizontal kneading machines (clay cutters), especially when a mixture of different materials is used.

The moulding of the bricks is carried out either by hand in wooden or iron moulds, or in special brick presses. Frequently the clay cutters are so arranged that the kneaded plastic mass passes out in the form of a long column, of which the section exactly corresponds to that of brick. The mass then only needs to be cut into the required lengths.

The moulded bricks are dried in sheds or artificially by the radiating heat of the kiln. HOFFMANN'S ring-kiln is generally used for burning the dried bricks. It consists of 12—20 chambers communicating with one another, each containing 5000—20000 bricks. The heating is carried out either with coal or with generator gas. One part of the kiln is still at a red heat while another is cooling, a third is being emptied, and a fourth is being refilled with dry bricks, and so on. The kiln gases on passing out warm the bricks which have just been brought in, and the heat passes round the kiln. This is brought about by different positions of the fire slides, &c.

The colour of the bricks varies according to composition, the nature of burning and the composition of the fire gases (oxidizing or reducing gases). Facing bricks are also coloured by means of metallic oxides, or are glazed.

Those bricks which have been heated too strongly are called clinker; the same name is also given to fire-proof stones or bricks, which are made of specially suitable clays with the addition of burnt brick dust.

For articles which must be specially uniform, such as facing bricks, &c., clays poor in lime are better than those rich in lime, or the calcareous fatty alluvial clays are mixed with fire-proof clay materials, such as fire-proof-brick-dust. Such facing bricks are very carefully moulded, and while being burnt are protected by suitable arrangements from flying ashes, &c., or still better the kiln is heated by gas.

Brine see **SALT**.

Briquettes. These are made from the small pieces of coal and brown coal by compressing them together. Some binding material is also usually added.

Brown coal briquettes are prepared without the addition of water. The material is first sorted, pieces about 3—4 mm are selected and dried in special ovens which are of different types. The press mostly used is that known as the extor press. Pitch and other materials mentioned below are used as binding agents.

For the manufacture of ordinary coal briquettes the fine coal or slack is used. The brown coal can be compressed directly into briquettes but the coal dust requires the addition of some cementing agent. For this purpose various kinds of pitch are added, about 10 % of the weight of the coal being necessary. The mixture is heated and pressed.

According to Germ. Pat. 141344 less pitch is necessary if the mixture is all melted together.

According to Germ. Pat. 136322 and 142862 the waste liquors from manufacture of sulphite cellulose are used as binding agents. For this purpose they are evaporated almost to dryness and tar-products, asphalt, resins, wax or glue are added.

This addition prevents the formation of a tough skin which would otherwise be formed from the volatile substances, and also insures the decomposition of unpleasant sulphur compounds derived from the waste liquors.

An improvement on this method is the object of Germ. Pat. 144819. The briquettes prepared as above are not stable to the action of the air on account of the solubility of the cementing agent. This objection is removed by heating the mixture to at least 120°; the alkali liquors are decomposed and the briquettes become more stable. Another improvement designed to obtain a powdery residue is protected by the Germ. Pat. 161675. The method consists in the removal of volatile constituents by drying in a current of air or gas or *in vacuo* and the resulting mass is obtained in the form of a fine powder so that breaking up the mass is unnecessary. A further improvement is described under the Germ. Pat. 173686.

According to Germ. Pat. 150041 brown coal briquettes may be prepared by mixing with the dust the residue of hair and wool obtained in the process

of the manufacture of glue. By adding a further small quantity of adhesive material a durable briquette is prepared by suitable pressing.

Germ. Pat. 144948 treats of the application of cement as a binding material. The method has been known but has found little application on account of the fact that different materials require different amounts of cement, which are destroyed by the heat. This objection can be removed according to the above patent by roasting the combustible matter before mixing with cement. The material is thus thoroughly incorporated with the cement and the briquettes do not fall to pieces in the fire. The rise in the amount of ash can be compensated by the addition of naphtha residues.

The increase in the numbers of patents connected with the manufacture of briquettes has recently become so great that only brief reference can be made to the most important of them.

Germ. Pat. 158497 states that the making of briquettes with a soluble cementing material is only possible, if the coal be rich in gas, by previously coking. The briquettes so obtained burn without flame. If they do not, then, according to the appendix to Germ. Pat. 186652, the coal is heated after the addition of the binding material until all the cementing material has become coked. Improvements in the coking of the water-soluble binding materials are described in the Germ. Pat. 174563 and 183280.

According to Germ. Pat. 186775 briquettes prepared from finely divided coal &c. with the addition of 1 % of chalk can be made stable by exposing them in a heated chamber to the action of hot HCl.

Machines for manufacturing Briquettes:

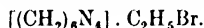
Werner Pfleiderer & Perkins Ltd., Peterborough.

Britannia metal see ANTIMONY ALLOYS.

British gums see „GUMS“.

Brockite see SAFETY EXPLOSIVES.

Bromaline = HEXAMETHYLENETETRAMINE-ETHYLBROMIDE.



Obtained by the action of ethylbromide on hexamethylenetetramine (see article UROTROPIN) in the presence of alcohol.

Colourless, crystalline powder, readily soluble in H_2O , which is given as a substitute for bromine salts as a sedative in neurasthenia and epilepsy.

Bromcamphor (CAMPHOR MONOBROMIDE) $\text{C}_{10}\text{H}_{15}\text{BrO}$. The following method of preparation can be recommended. 300 grm camphor are dissolved in 180 grms CHCl_3 , treated in a tubulated retort with 320 grms bromine, and the mixture allowed to stand for several days until it has been turned into a crystalline paste. The tube of the retort is closed with a safety tube, and the whole then gently warmed on a water bath. At the same time the fumes of Br which are formed are passed through a wide glass tube into H_2O . When no more fumes of HBr are evolved the retort and contents are allowed to stand in the cold for 24 hours, when the bromcamphor separates out. The crystals are separated from the mother liquor, washed with absol. alcohol, and recrystallized from hot ether until they appear pure white. If the solution of the crystals show acid reaction they must be washed with dilute Na_2CO_3 solution before the recrystallization.

Large, colourless crystals, with a weak camphor smell. M.P. 76° , B.P. 274° ; it sublimes below 100° . Soluble in 15 pts. alcohol, readily soluble in ether, chloroform, hot benzene, and fatty oils, almost insoluble in H_2O .

It is used in medicine, and is taken internally as a sedative, usually in doses of 0.1–0.5 grm.

Bromindigo see INDIGO DYES.

Bromine. Br. At. Wt. = 79.96. Bromine salts occur in sea water, in mineral springs, and in the abraum salts (see this) of the Stassfurt deposits. By far the larger amount of bromine is now obtained from the last-named source. The waste lyes of the carnallite manufacture are used for this purpose, the amount of bromine contained in them varying between 0.15 and 0.35 (usually 0.25—0.29) %.

According to PFEIFFER's continuous process, the bromine is set free from the magnesium bromide — in which state it occurs — by means of chlorine. The hot bromide solution percolates slowly through the interstices in a sand stone tower which is filled with clay balls, and meets on its way the ascending stream of chlorine. The bromine thus liberated is isolated by allowing the liquor to flow into a cauldron, driving out the bromine directly with steam, and allowing it to condense in earthenware cooling spirals. The purification of the crude bromine is carried out by distillation from glass retorts, usually over a bromine salt.

According to the Amer. Pat. 733466 a stream of air, which contains bromine as well as chlorine, should be passed through the mother liquors from the manufacture of NaCl; the chlorine is said to be absorbed by the liquid while the bromine, present in the form of salts, passes into the stream of gas. According to the Amer. Pat. 733467 of the same discoverer, vapours which contain bromine are passed into a solution of ammonium bromide and free NH_3 ; in this way the absorption of the Br is brought about.

Of late years the electrolytic manufacture of bromine has become specially important, for by the electrolysis of any bromide and chloride solution, the whole of the bromine is first separated. The solution is electrolysed until fumes of chlorine are evolved; it then is distilled when the bromine passes readily into the receiver. The most important starting point, for the electrolytic production of Br, is the waste liquors of the carnallite works. On account of the small percentage of Br, it is necessary to pass a large amount of the lye through the anode chamber of the bath; the liberated Br remains dissolved in the liquid and can be distilled off. The baths work at 80° ; carbon rods are used as anodes, and copper plates, placed in cathode chambers of porous porcelain as cathodes.

Another arrangement for preparing Br electrolytically is treated in the Germ. Pat. 134975. This contrivance consists of a column of alternate diaphragms and carbon electrodes, the diaphragms, placed close between the electrodes, being underneath, and the carbon electrodes above; the latter are provided with channels for the electrolyte — that is, for the waste bromide liquors. Further, the electrodes have channels leading to the top, by means of which the liberated H escapes.

The process protected by the Germ. Pat. 145879 seems to be full of promise. According to this the whole of the waste liquor is not electrolysed, but only a small portion (about 2 %), and the liquor, enriched with free chlorine, is passed uninterruptedly from a small bath into fresh liquor, while the magnesia, which swims on the surface as a thick foam, is held back and removed. The electrolysed liquor is run together with the fresh into a closed mixing box and passes thence into distillers, in which the Br is driven off with steam in the usual way.

The proposal, to precipitate the Br in the lyes as tribromphenol by treating with chlorine and phenol, and then to decompose this compound by burning or with $\text{Fe} + \text{H}_2\text{SO}_4$, seems as yet to have attained no practical importance. Br is a heavy, blackish-brown liquid, which gives off brownish-red fumes in the air, and possesses an unpleasant pungent smell. S. G. 3.1875 (at 0°) Becomes solid at -7.3° . B. P. 63° . 1 pt Br dissolves in 31 pts. H_2O (Bromine water). Saturated bromine water has the S. G. 1.02367. It dissolves more readily in alcohol, ether, and CS_2 , than in H_2O .

For disinfecting purposes, Br is converted into a solid form by absorbing it with kieselguhr. In addition to its use as a disinfectant, it is also used in the manufacture of tar dyes, for dissolving Au, as an oxidizing agent (instead of Cl), as well as for the preparation of Br compounds.

Bromine compounds. The bromides and bromates are to be found under the corresponding metals and radicles (e.g. POTASSIUM BROMIDE under POTASSIUM COMPOUNDS; ETHYLBROMIDE under ETHYL COMPOUNDS &c.). Iron bromide, hydrobromic acid, bromic acid, and bromoform are here described.

1. **IRON BROMIDE.** The fumes which are not condensed in the manufacture of bromine from the Stassfurt liquors — mostly chlorine and bromine — are passed over moistened iron filings. If it is wished perfectly free from Cl, then pure Br (free from Cl) must be heated, and the vapour allowed to act on the filings.

Iron bromide FeBr_2 crystallizes with 6 H_2O and contains 49.38 % Br, in the anhydrous state 74.07 %. When in solution it can absorb more bromine, and is converted into iron sesquibromide Fe_3Br_8 , with 79.2 % Br. It is manufactured because the liquid bromine is not carried on many railways.

The solution of iron sesquibromide is evaporated and solidified. The resulting brownish-black crystalline mass is valued according to the amount of Br it contains (65—70 %). It is chiefly used for the manufacture of KBr.

2. **HYDROBROMIC ACID HBr.** Usually only the aqueous solution is prepared for which purpose either NaBr (or KBr) is treated with dilute H_2SO_4 , or 10 pts. Br are allowed to drop on a mixture of 1 pt. red P and 15 pts. H_2O ; the whole being first gently heated and finally distilled. Concerning the French Pat. 352419 which aims at the direct combination of H and Cl and H and Br, see article on HYDROCHLORIC ACID.

HBr is a colourless, pungent, suffocating gas, which fumes very strongly in the air, and is very readily absorbed by H_2O .

The saturated aqueous solution has S. G. 1.78 at 0°.

3. **BROMIC ACID HBrO_3 .** The aqueous solution is obtained by the decomposition of barium bromate with H_2SO_4 , and evaporating the filtrate *in vacuo*. It can be concentrated until the solution corresponds to $\text{HBrO}_3 + 7 \text{H}_2\text{O}$ (with 50.6 % HBrO_3) without decomposition taking place.

Bromine Compounds:

Willy Manger, Dresden, Germany.

Bromipin (BROMINE FAT). Bromine addition product of sesame oil.

Yellow, pure oily-tasting liquid containing 10 % Br. It is taken internally as a non-irritating substitute for bromine salts, and also externally as ointment.

Bromleceithine see LECITHINE.

Bromocoll. Dibromtannin glue compound; it contains 20 % Br, 30 % tannin, 30 % glue, and 10 % H_2O . It is prepared by a special process, and is obtained when the product of the reaction of bromine with tannin is precipitated with glue.

Pale yellow, odourless and tasteless powder; given internally as a substitute for alkali bromides; further used externally as a powder or as an ointment for the treatment of wounds, ulcers, &c.

Bromoform (TRIBROMMETHANE) CHBr_3 . Is obtained from alcohol or acetone with Br and alkali lye or lime. It is also obtained from tribrompyrotartaric acid which decomposes on being heated with formation of oxalic acid and CHBr_3 . It is a secondary product in the manufacture of Br. Milk of lime is saturated with Br, alcohol added, and then the whole distilled.

Recently it has been obtained electrolytically (Germ. Pat. 29771) by the action of the current on a mixture of alkali bromide salt (dissolved in H_2O) and alcohol. Aldehyde or acetone may also be used in place of alcohol. The electrolysis is carried out in a hot solution, in an atmosphere of CO_2 .

$CHBr_3$ is a colourless liquid, resembling chloroform in smell, sparingly soluble in H_2O , miscible in all proportions with alcohol, ether, benzene, and petroleum ether. Very pure $CHBr_3$ has S. G. 2.904. M. P. 9° . B. P. $149-150^\circ$.

The official $CHBr_3$ contains 4 % alcohol and is more stable than that free from alcohol; it has S. G. of 2.829—2.833. M. P. 7° . B. P. $148-150^\circ$.

It is seldom used as a narcotic (inhalation); more often it is given internally as a sedative in cases of delirium, but above all for whooping cough in children.

Bromol = TRIBROMOPHENOL $C_6H_2(OH)Br_3$. Obtained as a white precipitate by the action of an aqueous bromine solution on dilute phenol. Also obtained by allowing the fumes of Br to act on phenol dissolved in glacial acetic acid.

Colourless, crystalline powder, almost insoluble in H_2O , readily soluble in alcohol, ether, and chloroform.

It is used externally as a caustic and disinfectant in the treatment of wounds; internally as an intestinal disinfectant in typhoid, diarrhoea, &c. $\frac{R}{1-2}$

Bromotan (BROMTANNIN METHYLENE UREA). Is a fine yellowish-brown powder insoluble in water which in combination with talc and ZnO has found use in the treatment of eczema and itching diseases.

Bromural. Monobromisovalerianyl urea $(CH_3)_2 \cdot CH \cdot CHBrCO \cdot NH \cdot CONH_2$. Is prepared by the condensation of urea with bromisovalerianyl bromide. It forms white almost tasteless crystals sparingly soluble in cold but readily in hot water, alcohol, ether. It is used as an hypnotic in doses of 0.3 to 0.6 grammes.

Bronzes. By bronze, strictly speaking, is meant only alloys of Cu and Sn but the name is now applied to other Cu alloys. The following kinds of bronzes are to be distinguished:

1. **DURANA METAL**, see under COPPER ALLOYS.
2. **BELL METAL**. (Consisting of 78—80 % Cu and 22—20 % Sn, at times even exceeding 25 % Sn). Bell bronze is readily fusible, melts to a thin liquid, is yellowish gray, hard, brittle, fine grained, and of strong tone.
3. **GUN METAL** (Consisting of 89—91 % Cu and 11—9 % Sn. At times 1—1.5 % Zn is added). The Uchatius bronze (steel bronze) consists of 92 % Cu and 8 % Sn. It is tougher but softer than the usual gun metal. Its special property is that the walls of guns made from this, (i. e. the rifling) become hardened by mechanical treatment at ordinary temperature (the driving through of steel rods by hydraulic pressure).
4. **ART BRONZE** (for statues, coins, medals, and ornamental objects). The composition varies very much — the genuine bronzes contain 80—90 % Cu and 5—8 % Sn. Besides these Pb and Zn are added, of which the former makes the working easier by diminishing the brittleness and toughness. The yellowish-red colour of the freshly cast bronze gradually changes on the surface owing to the action of the air into a deep brown tone with a bright green coating (Patina).
- For coins in the German empire (the so called "Copper coins"), an alloy of 95 % Cu, 4 % Sn and 1 % Zn is used. For medals a pure tin bronze with 5—10 % Sn is employed.
5. **MACHINE BRONZE**. Very many Cu-Sn alloys are used for making parts of machines, especially for axle bearings, slides, piston rod collars, blast furnace nozzles, ships's plates, cog wheels, &c. The majority of these alloys consist of 80—90 % Cu, 10—18 % Sn, and 2—4 % Zn; larger amounts of Zn (as well as Pb) are only used for bearing metals.

6. **MIRROR BRONZE.** Must be capable of taking a very high polish and be of as light a colour as possible. Also the polished surface must not easily tarnish. Only an alloy with a high percentage of Sn meets these requirements (28—35 % Sn), and the hardness is increased by the addition of a small amount of Ni.

7. **ALUMINIUM BRONZE.** An addition of Al to Cu alters the properties of the latter in a manner similar to Sn, but to a greater extent. For further information concerning Al bronzes, see **ALUMINIUM ALLOYS**.

8. **PHOSPHOR BRONZES.** An addition of P to those alloys termed bronzes increases the toughness and the ductility in a high degree. The P is added in the manufacture of phosphor bronze either in the form of copper phosphide (see **COPPER ALLOYS**), or tin phosphide (see **Sn ALLOYS**). The P serves the purpose of rendering the alloy free from O, and the excess of P in the finished bronze must not exceed a few tenths of a percent, otherwise the qualities are made worse instead of better.

As all bronzes may be treated with P, the composition of the alloys called phosphor bronzes is naturally very varying.

For some purposes bronzes are of value which contain up to 3 % P.

9. **MANGANESE BRONZE.** In these bronzes the Mn acts primarily as P, that is as a deoxidizing agent; but also secondly to a certain degree as a substitute for tin, so that the Mn may be added in excess without doing harm, and may form a constituent of the finished bronze. The Mn may be added in the form of Cupromanganese (see **MANGANESE ALLOYS**).

10. **SILICON BRONZE.** Si acts just as P, that is, as a deoxidizing agent; it greatly increases the toughness of bronzes poor in Sn, and decreases the ductility — which renders the Si bronzes specially adaptable for telephone wires. The brittleness increases greatly with the excess of Si. The latter may be added in the form of silicon aluminium, or silicon copper (see under **SILICON**). The manufacture of a special Si bronze of great tensile strength and toughness is protected by the Germ. Pat. 155908. According to this Cu, Zn, Al, and Si are melted together in the proportion of their atomic weights, — the Al being brought into the melted Zn, then the Si added, and finally the mixture so obtained poured into melted Cu.

11. **TUNGSTEN BRONZE** see under **TUNGSTEN ALLOYS**.

Bronze-foundry:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Bronze colours (BROCADE COLOURS). Powdered metals or metallic alloys not so finely powdered in the case of the brocade colours as of bronze colours. They are prepared from sheet metal or the waste products of the sheet metal manufactories by driving the tailings with the help of brush machines through sieves of increasing fineness. Finally the mass is moistened with gum water or solution of tragacanth and further ground in peculiarly constructed mills.

The alloys used for bronze colours consists, for light shades of 83 % Cu and 17 % Zn, for red of 90—94 % Cu and 10—6 % Zn. By washing, suspending, drying, and then carefully heating the ground bronze colours different shades are obtained, further by mixing the metallic powder with fat other colours are obtained.

For bronzing, the bronze colours are mixed with linseed oil varnish or the objects are painted with linseed oil varnish and the dry bronze colours sprinkled over while the varnish is still wet.

So-called liquid bronzes are varnishes in which bronze colours are suspended.

Brown coal see **FUELS**.

Brown coal tar. This is obtained by the dry distillation of bituminous brown coal and bituminous slates in upright cast-iron retorts, which are heated

by the gases of the distillation. Coke remains behind, the product of distillation is condensed; the aqueous part is treated like gas water for NH_3 , and the principal part is tar.

Brown coal tar forms a brownish yellow or black mass which at ordinary temperatures is soft and buttery, and melts between 15° — 30° C. to a dark green fluorescent liquid S. G. between 0.820 and 0.950; for good qualities S. G. average 0.840 (at 35°).

In working the tar, it is first warmed — very often first washed — and then distilled. Formerly a preliminary purification of the crude tar with H_2SO_4 was carried out, but this is now only very rarely done as it often causes resinification. The distillation is carried out in cast iron vessels, often under diminished pressure (vacuum distillation). Of late years the method of distilling with steam has come much to the fore. The first distillate, the crude oil, thus obtained is submitted to a chemical purification: it is treated with acids and lyes and then fractionated usually over caustic soda. In this fractional distillation photogen, solar oil, and gas oil, &c. are obtained. The second distillate of the crude tar consists for the greater part of paraffin, and is further purified. A part of the paraffin is also obtained directly from the crude tar on cooling.

According to the Germ. Pat. 175453, in the purification with H_2SO_4 the sulphates of alkali or alkaline earth metals should be added to prevent resins being formed. According to other researches the lessening of the action of the H_2SO_4 is not desirable because the quality of the product is thereby impaired.

Compare the articles on resinous gas, resinous paraffin, solar oil, &c.

Brucine $\text{C}_{23}\text{H}_{29}\text{N}_2\text{O}_4 + 4 \text{H}_2\text{O}$. Alkaloid, which is contained, together with strychnine (see this) in different *STRYCHNOS* species. It is obtained by evaporating mother liquors which are left in the preparation of strychnine nitrate, precipitating the bases present with NH_3 , and converting them into the oxalates. On evaporating brucine oxalate crystallizes out, while the strychnine oxalate remains in solution.

Colourless, transparent, extremely bitter-tasting crystals, which contain 4 mol. H_2O . The water of crystallization escapes when placed over H_2SO_4 , or by heating to 100° . Crystalline brucine dissolves very sparingly in H_2O but readily in alcohol and CHCl_3 . M. P. of the crystalline brucine is a little over 100° , that of the anhydrous compound 178° C.

It is a strong poison which is used medicinally. The free base, or its salts, are taken in the form of pills or drops containing 0.01—0.05—0.1 grm. Largest dose (per dose) 0.1 grm, per day 0.2 grm.

Brunswick green see **COPPER PAINTS**.

Burners.

Chemists' burners:

Gustav Barthel, Dresden-A. 19 (see front part advt.).

Burners for laboratories:

Gustav Barthel, Dresden-A. 19, Germany (see front part advt.).

Bunsen burners:

Gustav Barthel, Dresden-A. 19 (see front part advts.).

Burnishing, see **METAL COLOURING** as well as **RUST PROTECTING AGENTS**.

Butipyrin. This is the name given to an imitation of the commercial patented **TRIGEMIN**.

Butter. Usually only the cream and not the milk is churned. In factories the cream is separated, not by allowing the milk to stand in flat dishes, but by means of a milk separator, or centrifugal machine.

The mechanical movement necessary for turning cream into butter is performed in the churn, either in stationary stamping churns, or in rolling or cradle churns; of the latter some are built with perpendicular, and some with horizontal beaters.

The pressing out of the butter and the kneading of the mass is carried out on a large scale by means of the butter kneading machines. After being kneaded it is usually salted to make it keep better. On an average 1 kg butter is obtained from 24—30 l milk; by means of cream-separators the yield when compared with the other methods is increased by 10—20 %.

The investigations of POLLATSCHEK, as to why the butter turns brown and foams when roasted, show that the frothing is due to the presence of small amounts of soap and H_2O in the butter, while the principal cause of the brown colour is lecithine.

Composition of butter, according to KÖNIG (300 Analyses.)

	In natural butter						In the dry substance		
	Water %	Fat. %	Casein %	Milk sugar %	Lactic acids %	Salts %	Fat. %	Casein %	trogen %
1. Maximum	4.15	69.96	0.19	0.45		0.02	80.96	0.22	0.04
2. Minimum	35.12	86.15	4.78	1.16		15.08	98.70	5.53	0.88
3. Average	13.59	84.39	0.74	0.50	0.12	0.66*	97.64	0.86	0.14

* Only butter with less than 2 % salts is considered in the determination of average.

Compare also under MILK the articles for testing milk. Further see also MARGARINE and COCOANUT BUTTER.

Butter-milk preservatives see MILK PREPARATIONS.

Butyl alcohol $C_4H_9.OH$. Of the four isomerides the isobutyl alcohol (fermentation butyl alcohol) $(CH_3)_2.CH.CH_2.OH$ is especially important. It occurs in potato fusel oil and is obtained from this either by fractional distillation or by precipitation as the iodide.

Colourless liquid which smells of fusel oil and jasmine. S. G. (at 0°) 0.8168, B. P. $108.4^\circ C$.

Butyl alcohol:

C. Erdmann, Leipzig-Lindenau.

Butyric acid $C_4H_8O_2$. Of the two isomers only the normal butyric acid (ethyl acetic acid) $CH_3.CH_2.CH_2.CO_2H$ is of actual importance. It is obtained in "butyric acid fermentation" by mixing starch paste or boiled mashed potatoes with hot H_2O and a little tartaric acid and adding after a few days decomposing meat or cheese. It is also produced from sour skimmed milk by adding prepared chalk and leaving to stand in a warm place; the H_2O lost by evaporation is replaced from time to time: The calcium lactate, first formed is changed into calcium butyrate from which the acid is obtained by converting it into the sodium salt and setting free the acid with H_2SO_4 . By fractional distillation butyric acid can be separated from the other fatty acids formed at the same time.

Colourless, oily liquid of rancid smell and intensely acid taste, crystallizing in leaves at $-19^\circ C$. Boiling point 163° ; S. G. (at 14°) 0.9580. It mixes with H_2O , alcohol and ether, burns with a blue flame and forms crystalline salts most of which are soluble.

BUTYRIC ESTER (BUTYRIC ACID ETHYL ESTER) $C_3H_7.CO_2.C_2H_5$. Obtained by distillation of ethyl alcohol with once rectified butyric acid and H_2SO_4 . By distillation of carob fruit (St. JOHN's bread, fruit of carob tree — fermented with chalk) with alcohol and H_2SO_4 a butyric ether is also produced.

Colourless liquid with a pleasant fruity smell S. G. (at 18°) 0.90; B. P. 121°. It is used in the manufacture of artificial rum and of many fruit essences (see special article).

Butyric acid:

C. Erdmann, Leipzig-Lindenau.

Butyric acid ether:

C. Erdmann, Leipzig-Lindenau.

Butyrum cocoa see "COCOA BUTTER".

Byroline. Mixture of boric acid, wool fat, glycerine and H_2O . It is used or the skin.

C.

Cachou de Laval. A coal tar colouring matter of unknown constitution, obtained by melting organic substances such as bran, saw-dust etc with sodium sulphide. By freeing the substance from excess of sulphide of sodium and dissolving in alkaline sulphite the so-called cachou de Laval is obtained. It is a brown sulphur dye which dyes cotton directly: it is almost entirely used for the purpose of printing and dyeing cotton. After being dyed the materials are fixed by being placed in a bath of $K_2Cr_2O_7$ and H_2SO_4 .

Cacodyl preparations. Cacodylic acid and its salts have of late come much into use in medicine.

If dry potassium acetate be heated with equal parts of arsenious anhydride, an oil is obtained which has an extremely objectionable odour, B. P. 170° almost insoluble in water. This is the so called Cadet's fluid which contains a small quantity of cacodyl $As_2(CH_3)_4$ and much cacodyl oxide $As_2(CH_3)_4O$.

If this mixture be treated with mercuric oxide both compounds are oxidized to cacodylic acid i.e. dimethyl arsenic acid, $As(CH_3)_2O_2H$.

It forms crystals which dissolve readily in water and have no smell. It is a monobasic acid, the salts are soluble in water and are mostly amorphous.

Cadmium. Cd. Atomic weight = 112.0. The principal raw material from which cadmium is obtained is zinc dust. This dust is formed during the treatment of ores containing cadmium. It is brown and contains up to 30 % CdO (and $CdCO_3$). Cadmium is generally obtained by a dry process of fractional distillation, as it becomes gaseous at a comparatively low temperature. The distillation must be repeated several times.

A perfectly pure cadmium is obtained more simply by a wet process, viz. by treating the zinc and cadmium alloys with dilute H_2SO_4 . The zinc first dissolves, and being a more electro-positive metal it tends to precipitate the Cd. from the solution.

A new method of distillation (Germ. Pat. 132142) for obtaining a cadmium quite free from zinc is based on the property possessed by certain bodies of reducing cadmium compounds, especially CdO and $CdCO_3$ at a moderate red heat without reducing the compounds of other metals, such as ZnO and $ZnCO_3$. This process depends upon the fact that cadmium-containing zinc ores, associated with sufficient bituminous matter and the carbonates of iron and manganese are reduced directly without the addition of further quantities of these materials. In the case, however, of zinc dust, poussière &c. which are poor in these substances an addition of them is necessary.

According to Dr. CARL GOLDSCHMIDT cadmium can be separated from cadmium salts not only by zinc but also by Al. If a trace of chromium nitrate solution be added, the precipitation is complete. Cadmium is an almost silver white, hard, tough metal which becomes covered with a thin film of oxide on exposure to the air. Its specific gravity is 8.6. M. P. 320° , B. P. 770° . It dissolves readily in HNO_3 , less readily in dilute HCl and H_2SO_4 . It is used for making readily fusible alloys and also in dentistry for making cadmium amalgams.

Cadmium alloys. The alloys of cadmium are remarkable for being very easy to melt. Among the best known alloys are the following.

1. WOOD'S METAL consists of 1 part Cd, 2 pts. Pb, 4 pts. Sn. and 4 pts. Bi. It is very lustrous, almost silver-white, fairly flexible and has a melting point a little over 60° . It is used as a solder and was formerly also used in dentistry as a stopping.

2. LIFOWITZ'S ALLOY, a compound of 3 pts. Cd, 8 pts. Pb, 8 pts. Sn and 15 pts. Bi. M. P. 70° .

3. SOFT SOLDER made of 2 pts. Cd, 2 pts. Pb and 4 pts. of Sn. It is very tough and can be hammered and rolled.

Other cadmium alloys are employed for various purposes. Compare also the article ALUMINIUM ALLOYS No. 6.

Cadmium colours. Cadmiumsulphide, jaune brillant, is the only Cd compound used as a colour or pigment. It is a very beautiful brilliant colour very durable and fast to light. It is much prized by artists for its covering power, but at the same time it is very expensive. It is obtained by precipitation of solutions of cadmium with H_2S or sodium sulphide. The tint varies from lemon colour, pale yellow to deep orange according as the precipitate is obtained from a weakly or strongly acid solution.

It is also produced by electrolytical methods. A solution of common salt is electrolysed between cadmium electrodes and H_2S passed through the solution.

Cadmium compounds.

1. CADMIUM ACETATE $\text{Cd}(\text{C}_2\text{H}_3\text{O}_2)_2 + 3\text{H}_2\text{O}$. This compound is formed by dissolving CdO in $\text{C}_2\text{H}_3\text{O}_2$ and evaporating to the point of crystallization.

2. CADMIUM BROMIDE. $\text{CdBr}_2 + 4\text{H}_2\text{O}$. Obtained by digesting Cd (suspended in H_2O), with Br and then evaporating and crystallizing.

The crystals are long, colourless, deliquescent needles, which dissolve easily in H_2O and alcohol. At 100° 2 mol. and at 200° the rest of the water of crystallization are lost. The salt is used for photographic purposes.

3. CADMIUM CHLORIDE $\text{CdCl}_2 + 2\text{H}_2\text{O}$. Obtained in the form of deliquescent crystals by evaporating a solution of Cd in HCl .

CADMIUM IODIDE CdI_2 . This is obtained in the same way as cadmium bromide or by evaporating a solution of KI with CdSO_4 . Hexagonal leaves with a mother of pearl lustre which dissolve in water and alcohol. Cadmium iodide is used in photography.

4. CADMIUM OXIDE CdO . A substance produced by heating Cd to a red heat, or by heating CdCO_3 , CdSO_4 or $\text{Cd}(\text{NO}_3)_2$. It forms according to its method of preparation, either a brown infusible powder or blue-black microscopic octahedra, S. G. 8.1.

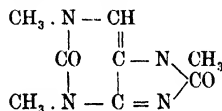
By precipitating dilute cadmium solutions or by digesting CdO with H_2O a white cadmium hydroxide is obtained, $\text{Cd}(\text{OH})_2$ which absorbs CO_2 from the air.

5. CADMIUM SULPHATE CdSO_4 . Is obtained by dissolving Cd in H_2SO_4 with the addition of HNO_3 and then evaporating. This salt contains varying amounts of water for instance $3\text{CdSO}_4 + 8\text{H}_2\text{O}$ and $\text{CdSO}_4 + 4\text{H}_2\text{O}$. The crystals are colourless and soluble in water.

6. CADMIUM SULPHIDE CdS see under CADMIUM COLOURS.

Caesium and CAESIUM COMPOUNDS. Caesium Cs, Atomic weight = 132.9. Metallic caesium is obtained, with a certain amount of difficulty, by the electrolysis of a fused mixture of caesium cyanide and barium cyanide. It is a silver-white, very soft metal which burns easily in air. S. G. at 15° 1.88. B. P. 240°, M. P. 26° to 27°. It is of no commercial value.

The caesium compounds resemble in every respect those of potassium. They were first discovered in the mother liquor of the „Dürkheimer salzsole.“ Caesium hydroxide is a very powerful base. Caesium platinumchloride, which is very insoluble in water, is of importance for separating caesium and potassium compounds from each other. Caesium alum, and caesium rubidium alum, are more frequently made use of. The first named is about 22 times as insoluble in water as potassium alum.

Caffeine (Theine. TRIMETHYL XANTHINE).

CAFFEINE is an alkaloid which is present in *Coffea arabica* and in *Thea Chinensis*.

It is usually prepared commercially from tea dust although this substance only contains 1.4 %. The tea dust is extracted several times with hot water; the liquor is then evaporated and the tannic acid is precipitated with milk of lime. After this the caffeine is obtained from the filtrate by treatment with alcohol. When the alcohol is distilled off the crude caffeine remains and is then dissolved in water, boiled with animal charcoal and finally purified by recrystallization.

Caffeine crystals are white silky needles which lose the water of crystallization at 100°. They sublime at 180°, M. P. 230.5. Caffeine dissolves in 80 pts of H₂O at 15° in 2 pts of boiling H₂O. It does not dissolve readily in alcohol, CS₂, C₆H₆, petroleum ether or ether but readily in CHCl₃. It is administered subcutaneously and also internally in cases of neuralgia, migraine and certain forms of heart trouble. Max. Dose 0.5 gr, max. daily dose 1.5 gr.

Testing of aqueous solutions of Caffeine with the Immersion Refractometer according to HANUS. Prosp. Meß 165:

Carl Zeiss, Jena (Germany).

Calcareous stone (artificial). For a long time attempts have been made to produce a building material, from a mixture of lime and sand, which would serve as a substitute for stone or bricks. It is a well known fact that the manufacture of bricks from clay is very dependent on climatic influences; this disadvantage would not come into question in making stones, bricks &c. from lime and sand. Again, clay bricks can only be made where clay is to be found, which renders the price extremely high when they have to be transported to any great distance. As sand is to be found every where, this objection would naturally be almost entirely removed. The process of making bricks from sand and lime is a very simple one. The bricks are pressed out of a mixture of lime and sand, in definite proportions, containing the proper amount of moisture.

A special press is used from which they are taken by hand and loaded into iron trucks. The loaded waggons are run on rails into a hardening chamber,

which is then closed. Steam pressure is applied for a specified length of time. During this time the stones go through the process of hardening, and when the waggons are again drawn out of the boiler the bricks are ready for use. The various methods for carrying out this process differ considerably in many points.

The stones or bricks are not only weather proof but also show great resistance to fire, and can therefore be used for constructing the masonry round boilers.

The Germ. Pat. 138935 and 151945 protect the manufacture of non-conducting lime and sand bricks, which are made from a mixture of lime sand and kieselgur containing more infusorial earth than is necessary for the formation of calcium silicate. After the treatment in the steam chamber, these stones can be burnt, in which case they may first be impregnated with water glass.

The objection that bricks of this nature lose their colour under the influence of rainy weather, is removed by the Germ. Pat. 158615 in a very simple manner. The stones after being hardened under steam pressure are glazed and then burned until the glaze melts and combines with the silicate of lime. The facing of such stones can be glazed so as to give different colours and tones.

Calc spar CaCO_3 . A naturally occurring calcium carbonate.

Calcium nitrogen. This designation is given by FRANK to raw calcium cyanamid, see CALCIUM COMPOUNDS.

Calcium Ca. Atomic weight = 40. Calcium is obtained from fused CaCl_2 by electrolysis with a carbon anode and an iron wire as cathode; the metal which is separated remains attached to the latter. Of the many proposals for lessening the difficulty of obtaining calcium that of RUFF and PLATO Germ. Pat. 153731 deserves most attention. They make use of a mixture of 100 pts of CaCl_2 with 16.5 pts. of CaF_2 which melts at 660° , that is at a lower temperature than the Ca itself (760°). It is electrolysed at 800° . Retort graphite serves as anode and iron wire as cathode. To the lower part of the iron wire a very thin steel wire is attached which becomes red hot by the passage of the current, 8 amp. at 8 volt. The Ca adheres to the wire; it contains 99.3% Ca. For obtaining large quantities the same mixture of salts is electrolysed in the well known MUTHMANN apparatus. The inventors have found that pure Ca can only then be profitably separated by electrolysis when the following conditions are observed. 1. The S.G. must be so high and the melting point so low that at the temperature of the electrolysis it is sufficiently fluid and yet dense enough to allow the globules of calcium to rise to the surface. 2. The mass must be free from foreign metals and silicates in order to prevent the formation of calcium alloys or calcium silicides; further any impurity of the resulting metal would cause the calcium particles to melt together to form larger masses. 3. The temperature during the process must be kept as little as possible above the melting point.

According to Germ. Pat. 144667 small cathodes and large anodes are used for electrolyzing fused CaCl_2 . The temperature is kept below the melting point of Ca. Under these conditions the Ca separates and adheres to the cathode as a spongy mass, which can be compressed by the use of special tongs to a solid mass of metal, before being removed from the electrolyte. The metal so obtained contains about 90 % Ca and can be used in this state for many purposes. Should it be necessary to remove the salts contained in the metal or otherwise to purify it, it is carefully melted with exclusion of air.

According to Germ. Pat. 155433 the electrode to which the melted Ca is to adhere is very gradually withdrawn so that the metal is deposited in a compact form as a rod. It is also advantageous to keep the cathode in a vertical position and to allow only the end, to dip below the surface of the electrolyte.

7. Until quite recently Ca had no technical value whatsoever, but it is now increasing in importance. It is prepared in the form of thick rods which come into the market packed in tin canisters.

The metal is of a light yellow colour, is ductile and malleable. It is harder than tin, and very stable in dry air S. G. 1.5778. It only melts at a red heat. In damp air it readily oxidises. It decomposes water at a low temperature Ca is well adapted for reducing purposes and for GRIGNARD's reaction in which it replaces Mg. Finally some alloys of Ca have been obtained for which see ALUMINIUM ALLOYS No. 12.

Calcium compounds.

1. CALCIUM ACETATE $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2\text{H}_2\text{O}$. Prepared in large quantities, from pyroligneous acid by neutralizing with $\text{Ca}(\text{OH})_2$ acidifying with HCl separating off the tarry matters neutralizing with lime, evaporating and separating the crystals. The moist product is dried at 75° and then heated to 120° to remove the adhering empyreumatic substances. Purification is effected by recrystallization. Compare ACETIC ACID.

2. CALCIUM BISULPHATE see CALCIUM SULPHITE.

3. CALCIUM CARBIDE see CARBIDES.

4. CALCIUM CARBONATE CaCO_3 is found in nature in the form of marble, chalk and limestone. It is obtained artificially by precipitating solutions of calcium salts with CO_2 or carbonates. See also the article CALC SPAR.

Wesenfeld, Dicke & Cie., Barmen-R., Germany.

5. CALCIUM CHLORIDE CaCl_2 . Is obtained in large quantities as a by-product in the ammonia-soda process, in the manufacture of chlorine and in various other processes.

It is obtained in a pure state by dissolving CaCO_3 (marble or chalk) in HCl.

Calcium chloride is colourless, has a bitter taste and crystallizes from highly concentrated solutions in a columnar form with 6 mol. H_2O M. P. 29° . The crystals deliquesce on being exposed to the air; much heat is absorbed when this hydrate is dissolved in water. On heating 4 mol. H_2O escape very readily the last two however only when a temperature of 200° is reached. It then forms a white mass, porous calcium chloride CaCl_2 , which melts at 806° and forms on solidifying a coarse crystalline somewhat fluorescent mass.

The dry CaCl_2 absorbs the atmospheric moisture so readily that it is largely used as a drying agent.

6. CALCIUM CHROMATE CaCrO_4 . Obtained for technical purposes by heating chrome iron ore with chalk. The pure compound is made by precipitating solutions of chromates with Ca salts.

7. CALCIUM CITRATE. Obtained by the precipitation at boiling heat of lemon-juice with finely divided chalk.

8. CALCIUM CYANAMIDE CaCN_2 . The process for obtaining this product is described by FRANK in his Germ. Pat. 88363, 92587, 95660, 108971, 116087, 116088, 141624 and 150878. Atmospheric nitrogen is conducted over melted Ca_2 with the addition of NaCl as a flux. The fusion can be carried in muffle furnaces and also in electric furnaces; in this way 85—95% of the theoretical quantity of N is absorbed forming a black mass of calcium cyanamide containing 20—23.5 % of N. Still more practical is a modification of the process which consists in leading N directly over a heated mixture of CaO and C in a electric furnace. The change is represented by the equation $\text{CaO} + 2\text{C} + 2\text{N} = \text{CaCN}_2 + \text{CO}$. If the calcium cyanamide be then lixiviated with H_2O the result will be dicyandiamide $(\text{CNNH}_2)_2$ as a white salt.



Dicyandiamide can be worked up directly into sodium or potassium cyanide. The crude calcium cyanamide to which FRANK has given the name of calcium nitride is used for manure. This provides a practical method of obtaining nitrogen from the air.

According to Germ. Pat. 163320 in order to prepare calcium cyanamide the carbide is treated with a chloride (e. g. the specification mentions 23 % of CaCl_2), with the result that the reaction is almost complete and takes place at a lower temperature.

CARLSON (Stockholm) employs CaF_2 instead of CaCl_2 with the result that the product keeps better.

Careful experiments have shown that this substance forms an excellent manure, yielding nitrogen through its decomposition in the earth.

WAGNER and GERLACH assert that the nitrogen given in the form of calcium cyanamide is almost equal in its effects in the cultivation of various kinds of plants to the same quantity of nitrogen in the form of ammonia salts. Also that it is almost equal to nitre as a manure. For many purposes the lime contents of nitro calcium compound are troublesome and harmful when used as manure. The Germ. Pat. 154505 provides a method for the removal of the lime from the substance in question, by transforming the lime into cyanamide CN_2H_2 . The removal of the lime can also be carried out according to the Germ. Pat. 108971 by extraction with hot H_2O , when the nitrogen compounds pass into solution. These compounds, which contain up to 66 % of nitrogen, can be mixed with either potash or phosphatic manures as may be necessary.

9. CALCIUM CYANIDE $\text{Ca}(\text{CN})_2$. This compound, according to ERLWEIN and FRANK, Amer. Pat. 708333, is obtained by heating a mixture of calcium cyanamide (see above), carbon and NaCl to fusion. The impure mass resulting is said to serve as a substitute for alkali cyanide.

10. CALCIUM FLUORIDE CaF_2 . Occurs in nature as fluor spar in the form of beautiful crystals, which when chemically pure are colourless, but which are, however, on account of the presence of foreign substances, usually coloured blue, violet red, green, or yellow. CaF_2 is obtained artificially by heating cryolite $\text{Al}_2\text{F}_6 \cdot 6\text{NaF}$ with CaCO_3 , or by boiling cryolite with lime. It is also obtained chemically pure by the precipitation of weak KF solutions with CaCl_2 .

11. CALCIUM NITRATE $\text{Ca}(\text{NO}_3)_2$. Found most frequently in Venezuela; forms an excellent manure. In a purified state it is used in incandescent gas works. According to the Austrian Pat. 28352 (1907) $\text{Ca}(\text{NO}_3)_2$ is obtained from liquors containing CaCl_2 (e. g. the residues in the ammonia-soda manufacture) by treating them with NaNO_3 . An equivalent amount of the latter is used and the mixture heated to boiling point (127°) and evaporated at atmospheric pressure.

With reference to the preparation of $\text{Ca}(\text{NO}_3)_2$ from atmospheric nitrogen by the interesting method due to BIRKELAND and EYDE, compare the article on NITRIC ACID.

It forms a deliquescent salt, crystallizing in prisms; is insoluble in alcohol. Used as an artificial manure.

12. CALCIUM OXALATE CaC_2O_4 . For the artificial process of obtaining this compound see OXALIC ACID. The pure product is obtained by precipitating alkaline or acetic acid solutions of Ca salts with oxalic acid or oxalates.

13. CALCIUM OXIDES.

a) CALCIUM OXIDE CaO , see art. LIME.

b) CALCIUM HYDROXIDE $\text{Ca}(\text{OH})_2$, see art. LIME.

c) CALCIUM PEROXIDE CaO_2 can be obtained by treating lime water with peroxide of hydrogen, but is now largely prepared from sodium peroxide,

by the action of a calcium salt. Compare article SODIUM COMPOUNDS. The Germ. Pat. 128617 and 132706 describe another process, that of compressing a mixture of peroxide of sodium and calcium hydroxide in molecular proportions into little cylinders and then treating these with ice cold water. The hydrate of calcium peroxide thus formed is filtered off, washed and dried.

According to the Amer. Pat. 847670 CaO_2 may be prepared by the action of a solution of H_2O_2 on a solution of calcium chloride. On the addition of concentrated ammonia solution the hydrate of calcium peroxide is precipitated. According to the French. Pat. 364249, a solution of H_2O_2 obtained by the action of acid on Na_2O_2 , is allowed to act upon quick lime or precipitated $\text{Ca}(\text{OH})_2$. CaO_2 is used instead of H_2O_2 for bleaching.

14. CALCIUM PERMANGANATE CaMn_2O_8 . This compound is obtained by treating KMnO_4 with a Ca compound. According to Germ. Pat. 145368 it is obtained electrolytically at the anode, when the electrolysis is carried out with a diaphragm, the kathode compartment containing at first CaCl_2 and the anode compartment KMnO_4 solution + CaCl_2 . It dissolves very readily in H_2O so that extremely strong solutions can be used. The cold saturated solution has a S. G. 1.8. Since it possesses great oxidizing power, so great that alcohol into which CaMn_2O_8 is dropped catches fire, it is employed as a disinfectant and for purifying sugar-syrup.

15. CALCIUM PHOSPHATE.

a) TRI-CALCIUM PHOSPHATE $\text{Ca}_3(\text{PO}_4)_2$. Occurs as the mineral phosphorite. It is the principal constituent of bone ash which contains about 80 %. It is obtained artificially by precipitating an ammoniacal solution of CaCl_2 with sodium phosphate.

b) DI-CALCIUM PHOSPHATE, acid calcium phosphate $\text{CaHPO}_4 + 2\text{H}_2\text{O}$ is obtained in the form of a crystalline precipitate insoluble in water by precipitating a CaCl_2 solution, acidified with acetic acid, with disodium phosphate Na_2HPO_4 . According to the Engl. Pat. 14194 (1903) the following method can be employed. Phosphates in the form of bones, animal charcoal &c. are heated sufficiently to destroy the organic substances, then treated with weak HNO_3 or HCl . After this the insoluble portions are separated and the dicalcium phosphate is precipitated from the solution by CaCO_3 . This patent has as little practical importance as the Eng. Pat. 19267 (1903) which likewise protects a method for obtaining dicalcium phosphate.

c) MONOCALCIUM PHOSPHATE $\text{CaH}_2(\text{PO}_4)_2 + \text{H}_2\text{O}$. Obtained by dissolving one of the other two calcium phosphates in acid and then evaporating the solution.

The salt, which dissolves with difficulty, is of technical importance. It is used for the manufacture of phosphorus and also as an artificial manure. See also SUPERPHOSPHATE.

16. CALCIUM PLUMBATE see LEAD COMPOUNDS No. 20.

17. CALCIUM SULPHOCYANIDE $\text{Ca}(\text{CNS})_2 + 3\text{H}_2\text{O}$. This compound is obtained by decomposing crude ammonium sulphocyanide solutions (see SULPHOCYANIDE COMPOUNDS) with calcium hydroxide, the NH_3 being expelled as quickly as possible by the introduction of steam. The lye is evaporated to a density of 45° Bé when the calcium sulphocyanide crystallizes on cooling. According to the Eng. Pat. 22710 (1902) it can be obtained from coal-gas and other gases containing cyanogen by treating them with a mixture of slaked lime and sulphur. The materials can be mixed while damp and used as a gas purifier, or mixed with water, they can be used in a scrubber tower.

18. CALCIUM SULPHATE CaSO_4 . This compound is found in the anhydrous form as anhydrite and hydrated as gypsum. For further details see GYPSUM.

Calcium sulphate is made artificially for many purposes by precipitating concentrated calcium solutions with a soluble sulphate or with H_2SO_4 . Accord-

ding to the Eng. Pat. 14112 and 14194 (1903) calcium phosphate is dissolved in dilute HNO_3 or HCl , dicalcium phosphate is precipitated with CaCO_3 and the filtrate treated with H_2SO_4 .

19. CALCIUM SULPHIDE (liver of sulphur) is used in the leather industry as a depilating agent. It is however, generally employed in the form of a mixture of milk of lime and arsenic sulphide.

20. CALCIUM SULPHITE.

a) Neutral calcium sulphite CaSO_3 . This was formerly always obtained artificially by treating slaked lime with SO_2 . The lime must be spread in thin layers. The SO_2 gas is obtained by burning S. The heat generated during the process is sufficient to evaporate the water and thus to prevent the formation of calcium bisulphite; at present it is often obtained by allowing the gases from pyrites ovens to act upon lime stone, CaCO_3 kept moist by allowing water to trickle over it. Care must however be taken to avoid excess of SO_2 , as otherwise calcium bisulphite would be formed which would pass into solution.

Neutral calcium sulphite is a white powder which scarcely dissolves in water. It is used in the solid form. It is principally employed as a convenient source of SO_2 .

b) CALCIUM BISULPHITE $\text{CaH}_2(\text{SO}_3)_2$ can be obtained by dissolving CaSO_3 in a solution of SO_2 but for practical purposes it is always obtained by leading SO_2 (the gases from pyrites ovens) over moist porous limestone. This process is carried out on a large scale to get rid of the SO_2 from the furnace gases which are so harmful to vegetation. The gases are conducted into towers filled with limestone pieces over which water trickles. CO_2 escapes while from the bottom of the tower a solution of calcium bisulphite is drawn off.

A special apparatus for the preparation of solutions of calcium bisulphite is protected by Amer. Pat. 846499. It comes into the market as a solution which is used on a large scale for making wood cellulose for paper manufacture; see CELLULOSE.

21. CALCIUM THIOSULPHATE CaS_2O_3 is almost entirely obtained from the alkali waste of the **LEBLANC** process which is very rich in CaS , by allowing the calcium sulphide to oxidize to thiosulphate or by hastening the oxidation by pumping air into the waste. The CaS is also often dissolved by boiling with S and the conversion into thiosulphate is completed by conducting SO_2 into the solution.

It serves for the preparation of other thiosulphates and of antimony sulphide.

22. CHLORIDE OF LIME see Bleaching powder.

Calcium Compounds:

Willy Manger, Dresden, Germany.

Calmine. A mixture of di-methyl-phenyl-pyrazolone and di-acetyl-morphine, see **ANTIPYRINE**. The mixture is used medicinally for coughs, whooping-cough, asthma and in cases of painful menstruation.

Calodal. A pure albumen preparation made from meat. The albumen, which is finely divided, contains the original phosphates of the meat and is very easily assimilated by the stomach, intestines or skin. It has therefore great nutritive and stimulating properties. It is a light yellowish-brown powder, easily soluble in H_2O . The solution remains clear on boiling and consequently can be easily sterilised.

Calodal is an important preparation for feeding *per rectum* or through the skin.

Calomel mercurous chloride, see **MERCURY COMPOUNDS**.

Calomelol, colloidal calomel containing 75 % Hg_2Cl_2 and 25 % albumen salt.

Calorimetry. cf. FUELS. The calorimeter is used for measuring accurately the calorific power of fuels. By burning a sample with oxygen in a closed vessel and determining the rise of temperature of the water surrounding the vessel, the heat developed can be calculated.

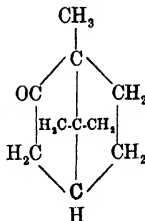
Different kinds are used, of which the bomb calorimeter deserves special mention.

Campeachy wood, see VEGETABLE COLOURS.

Camphene see TERPENES.

Camphor. The stearoptene (solidifying constituent) of the ethereal oil of the camphor tree, *Laurus camphora*, a native of China and Japan. It is obtained by boiling the chips in water until the camphor floats to the surface. This layer after cooling, separates as a solid mass. Another method is to distil the material with H_2O . It is refined by subliming the crude camphor after mixing it with carbon and quicklime.

Although the investigation of the constitution of camphor is one of the oldest problems of organic chemistry yet special attention has been aroused in this subject during the last few years. It is ascertained that beyond doubt it is a cyclic terpene ketone of the composition $\text{C}_{10}\text{H}_{16}\text{O}$. BREDT claims for it the following formula.



It stands in near relationship to BORNEOL, q. v., as borneol is oxidized to camphor by hypochlorous acid, while on the contrary, camphor passes into borneol on being reduced.

As quite a number of terpenes can be changed into camphor or its derivatives by oxidizing agents, many experiments have been carried out with the object of obtaining artificial camphor. The following method protected by the Germ. Pat. 134553 therefore caused considerable interest. Anhydrous turpentine is heated for some time with anhydrous oxalic acid at a temperature of 120–130°. This forms a mixture which contains camphor, pinyl formate and pinyl oxalate. The mixture is washed with water and the formate and oxalate are saponified, whereby the above-named compounds separate into borneol and camphor. The mixture can be distilled and the borneol oxidized with $\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4$ to camphor.

It would be a great mistake to suppose that this is the only process of obtaining camphor by artificial means.

All these methods and experiments have one point in common, viz: that they start from turpentine oil or the pinene contained in it; pinene is a terpene, $\text{C}_{10}\text{H}_{16}$, which differs from camphor only in containing one O atom less. In all the known methods for the production of artificial camphor the pinene is first changed into borneol $\text{C}_{10}\text{H}_{17}\text{OH}$ or rather into the isomeric isoborneol the latter then being oxidized to camphor.

The conversion of the pinene into borneol is carried out according to the method alluded to above by means of oxalic acid; according to other methods, however, by means of HCl. The following may be mentioned among the more recent methods. The French Pat. 339504 runs thus: turpentine and salicylic acid are heated with or without acetic anhydride. The uncombined salicylic acid is then removed by cold caustic soda solution and the uncombined oil removed by steam distillation whereupon the isobornyl ester is transformed by heating with soda solution into borneol and isoborneol. The Amer. Pat. 779377 apparently treats of the same process.

According to French Pat. 349896 the pinene is converted into the hydrochloride and the latter is then heated under pressure with acetate of lead in acetic acid solution. Camphene is thus formed which is easily oxidized to camphor by means of permanganate.

The French Pat. 349852 is as follows. Pinene hydrochloride is first produced and this is then converted by means of a formate into bornyl formyl ester, which on saponification yields borncol.

The Eng. Pat. 14189 (1904) treats of the purification of pinene hydro chloride as a preparatory step in the preparation of camphor. It recommends heating the crude product with a saponifying agent and after separation, washing, and freeing from oily impurities by concentrated H_2SO_4 , distilling in steam. The oily impurities are converted into rosin.

The second phase of the preparation of artificial camphor consists of the oxidation of the isoborneol to camphor.

According to Germ. Pat. 157590 and 161306 it is better not to treat the borneol or isoborneol with oxidizing agents, since in this way a residue is left, but to dissolve the borneol in benzene or petroleum ether and then to act upon it with aqueous alkaline permanganate solution (according to the former patent) or then to perform the oxidation by leading ozone into the solution (according to the second patent).

The French Pat. 352888 treats of the oxidation of the isoborneol, dissolved in benzene, by chlorine water, or by the action of chlorine on the dry substance.

Germ. Pat. 158717 recommends the oxidation without previous saponification of the isobornyl ester resulting from the treatment of pinene with acids. For this purpose, chromic acid, permanganate, nitric acid or other oxidizing agents are employed, an acid not oxidized by these being also added e. g. acetic acid.

Germ. Pat. 161253 and the additional pat. 166722 protect a method in which the borneol or isoborneol is oxidized by oxygen or air. Part of the original compound is converted into camphor which is obtained pure by sublimation.

The synthetic methods for the preparation of camphor may be here summarized (from an account by A. HEMPEL in Chem.-Ztg. 1907 p. 6 et seq. Four main groups are recognized.

1. By the action of acids on oil of turpentine. Germ. Pat. 134553. French. Pat. 339504.

2. By the action of acetates on pinene hydrochloride. French. Pat. 349896 and 349852.

3. By the action of magnesium on pinene hydrochloride. According to Germ. Pat. 34107 and 34167 A. HESSE employs GRIGNARD's reaction for the direct preparation of camphor.

4. By the conversion of pinene hydrochloride into camphene, reduction of this to isoborneol and oxidation of the latter to camphor.

Germ. Pat. 67255, 149791, 153924, 154107 &c. Camphor is a white crystalline substance with an oily lustre. It is tough, but at the same time readily crumbles. It has a peculiar odour and a burning taste. Almost

insoluble in H_2O , but readily in alcohol, ether, chloroform, oils &c. M. P. 175° , B. P. 204° . S. G. in compact form 0.922 (10%), 0.995 (15%). It is most easily powdered after moistening with alcohol.

It is employed in medicine, as a preventive against moths, in the manufacture of night-lights and fire works, and in large quantities for making celluloid (q. v.).

Allied to true camphor is borneol, known as Borneo or Sumatra camphor.

Camphor, Oil of. Is a by-product in the preparation of camphor, and is chiefly prepared in Japan. According to SCHIMMEL's Report it comes into the market in three forms, viz. as crude, white or red oil.

The crude oil is prepared by the distillation of the camphor chips with steam. The small particles of camphor are mechanically removed and the liquid left is a strongly smelling oil, transparent, of a brownish to yellowish colour, and a S. G. 0.95 to 0.995. From this crude oil, after removal of the camphor the white oil is obtained by fractional distillation. It is a colourless very mobile oil with a strong smell of camphor. By continued distillation the red oil is obtained as the fraction coming over below 200° . It contains safrol, eugenol and traces of camphor.

Recently modifications have been introduced in the manufacture of this substance, and the following kinds are now recognised. White or light camphor oil (S. G. up to 0.890). Dark or heavy oil (S. G. from 0.900 to 1.00) and blue viscid oil (S. G. 0.95 to 0.96).

The last-named is used in porcelain painting and can be employed as a substitute for oil of cloves.

Camphoric acid. Obtained by the action of nitric acid on fused camphor. It forms colourless, odourless plates, M. P. 186° to 187° . It is a dibasic acid and forms salts known as camphorates.

It is used medicinally, externally for boils and inflammatory troubles, and internally in the night sweats of phthisis.

Camphor naphthol. A product of the condensation of camphor and β -naphthol which is said to be of value in medicine. Its use has, however, of late been strongly condemned on account of its strong toxic properties.

Canada balsam (BALSAMUM CANADENSE). A balsam obtained from *Abies balsamica*. A horizontal cut is made in the bark in early spring and a piece is taken out. The balsam flows out and is collected in vessels placed under the cut. It is purified by filtration.

The balsam is clear and transparent, at first colourless and later pale yellow and of the consistency of honey. When left undisturbed it slowly solidifies. S. G. 0.985 to 0.999 at 15° . Refractive index 1.528. Completely soluble in ether, benzene, chloroform and carbon disulphide. It is used for cementing optical lenses, for mounting microscopic preparations &c.

Candles. These are now but rarely made of tallow. They are chiefly manufactured from bees wax, vegetable wax, stearine, stearic acid, paraffin or spermaceti. According to Germ. Pat. 136917 the acid derivatives of aromatic bases can be used either alone or mixed with the fats and higher fatty acids, as by this means the M. P. is raised. The anilide of stearic acid can thus be employed. The wide spread error, that the whiter the candles are the better is the quality of composition candles, has given rise to the use of substitutes being worked up with the paraffin cheaper than stearine which lessens the transparency. For instance the Germ. Pat. 157402 describes a method of partially substituting some paraffin oil for stearine, while the Swedish Pat. 18573 (1903) mentions paraffin oil and ketones as substitutes.

The wick of a candle is made of cotton and is either twisted or plaited. There are also wicks made of asbestos and of linen. To increase the burning power of the wicks (if plaited), they can be impregnated with KNO_3 or KClO_3 . This kind can also be treated with weak H_2SO_4 or they can be saturated with substances which by melting together with the ash of the wick ash cause the ashes to fall, thus securing the even burning of the candle. Substances for weighting the wick in this fashion are borax, boric acid, ammonium phosphate, and ammonium sulphate.

According to the Germ. Pat. 158928 the wick is impregnated, at the end projecting from the body of the candle, with a solution of celluloid in acetone to facilitate the lighting.

The candles are shaped by drawing, pouring into moulds or pressing. Stearine, paraffin, and spermaceti candles are always formed by pouring into moulds.

The drawing process is as follows. 16 to 18 wicks are fastened to a wooden spit (wick spit). This is dipped into the melted composition and then drawn out again and allowed to cool. The operation being repeated 4 or 5 times till the desired thickness is obtained.

The moulding of candles is however the general method and is done in special moulding machines. The moulds are in groups of 100—200 and are made of a tin-lead alloy.

The best candles are those made of paraffin (see PARAFFIN) with 1—2 % stearic acid. The paraffin is heated to 70—80°, the moulding machine is warmed by steam and the filled forms are then immediately dipped into water to cool. Of late it has become usual to add a small quantity of alcohol to the mass when ready to be poured into the moulds. This ensures a good, crystalline, snow-white candle which is so very similar to the stearine candles that they find a very ready market.

The candles made of stearine (see STEARINE), are poured into moulds in the same way only the work must be carried out at as low a temperature as possible, that is but little over the solidifying temperature of the material. The composition candles so much in use are made with a soft core and a hard outer covering of stearine. They consist of a mixture of paraffin and stearine.

Of late a new article "hard spirit" wax candles has come into use. These give a whiter light than the stearine candles. The light is said to be more powerful and the economy of material greater than that of stearine candles while the price is less. When the candles are taken from the moulds they are trimmed and polished. All candles without exception which are coloured are dyed with organic pigments as mineral dyes would stop up the wick and affect the burning power of the candle.

Cannabinol. The active constituent of Indian Hemp. Pale yellow thick fluid, soluble in alcohol and ether, oxidizes in the air. B. P. 215° (under a pressure of 5 mm).

Caoutchouc (INDIA RUBBER) is a product of the milky juices of various tropical trees, belonging to the family of the APOCYNACEAE, also to the MORACEAE and the EUPHORBIACEAE. The juices are obtained by boring holes in the bark and fixing a nest shaped cup under the hole so that the liquid trickles into it. Several methods are made use of for obtaining the crude caoutchouc from the milky juice. Inferior kinds are obtained by leading the juice from the tree directly into trenches, where it is left to dry; or by inducing it to coagulate by adding acids, plant juices &c., and then pressing and drying. A better quality is obtained by diluting the juice with H_2O , letting it stand, and then skimming off the thick cream which rises to the top, and after washing this with H_2O drying it in the sun or in smoke. The best and most valuable kind, Para rubber, is obtained by laying the juice in a mould (clay

bottles, spheres &c.) in a thin layer and letting it dry in hot smoke, then placing a second layer and repeating the process again and again. In this way sometimes as many as 100 layers are formed one over the other, each layer being less than 0,5 mm thick. The layers are white to dark-grey and are divided by black lines from each other. The "PARA SECONDS" consists of much thicker layers.

The raw rubber contains, besides the real caoutchouc varying amounts of organic impurities, which are called caoutchouc resins. The nature of these substances is at present not yet clearly defined. They differ however from the rubber proper in that they are soluble in alcohol and in acetone. Raw rubber contains other impurities such as water, sand, stones, clay, leaves, bark, &c.

The purification of the crude caoutchouc is carried out with the object of removing any moisture and the inorganic and organic impurities; the resins are left in the product.

The purification of caoutchouc is carried out in the same way as that of GUTTA PERCHA (see this article). It is softened in water, cut with a circular or Dutch knife and then treated with cold water to remove the mineral and vegetable impurities. After this it is put several times through a rolling or kneading machine, and finally dried at a temperature of 40–50° to remove the last traces of water. The pure substance thus obtained, which varies from black to brown according to its origin, is "thickened" in a mixing roller machine, the so called "masticator". In this way all pores are removed. The necessary mixtures are added in the mixing machine, before it is worked up into the different kinds.

Caoutchouc has only become of value since a method was invented for vulcanizing it. This process consists in treating the caoutchouc with sulphur at a fairly high temperature. The resulting product is one in which the elasticity is less influenced by temperature and which is much more resistant towards chemicals than the original substance.

The process of vulcanizing is carried out by mixing the rubber in the roller mill with sulphur, till thoroughly kneaded together. The substance is then heated in vulcanizing ovens, or better still in steam apparatus, to a temperature of 110–140°. There are several other methods for vulcanising in which instead of sulphur various compounds of sulphur are employed. Of these methods PARKE'S, in which chloride of sulphur is used, is the most important. (see the article CHLORINE COMPOUNDS). With a solution of this substance, chloride of sulphur in carbon disulphide the vulcanization takes place by simply dipping the rubber into it, without raising the temperature. If the articles are thick they must be dipped several times.

By vulcanizing the caoutchouc longer than usual with up to 75 % of sulphur or metallic sulphides with an addition of gypsum, chalk or other filling and colouring materials, the well known materials EBONITE and VULCANITE, are obtained. Ebonite can however be obtained with a smaller amount of sulphur, but in this case the vulcanization takes a longer time. The English Pat. 7795 of 1904 is not very clear and also sounds questionable. It asserts that ebonite articles can be made from a substance produced by heating crude milled rubber, with or without sulphur, to 150–200° under 500 atm. pressure, and adding to the product resulting from this operation mica, asbestos, carbon, tar, or melted resin.

Rubber is grey, brown or black, according to the method of production. It dissolves readily in carbon disulphide and some other fluids, but is insoluble in H₂O. When cold it is hard, at ordinary temperature it is very elastic and when heated it becomes sticky and of the consistency of tar. Vulcanized caoutchouc is insoluble in almost all known solvents, is scarcely attacked by chemical agents and to a certain degree remains almost uninfluenced by

variations of temperature. Caoutchouc is coloured white with zinc white, red, with sulphide of antimony, &c.

Compare also the article CAOUTCHOUC SUBSTITUTES. WEBER, (London) has proposed "POLYPRENE" as a chemical name for caoutchouc, founding the name upon the supposition that all members of this group are isomers of isoprene. The empirical formula for caoutchouc is $C_{10}H_{16}$ and its molecular weight is a multiple of that of the terpenes.

The methods for the recovery of caoutchouc (the working up of old stuff into new articles) become more important every day. Until lately, only the two following methods were used. 1. The caoutchouc was finely ground, sifted to separate the coarser pieces, then steamed under about 6 atm. pressure and finally rolled into sheets. 2. The old rubber was torn up in pieces of about 1 sq. cm section by placing between ribbed rollers, after which the whole was boiled, with dilute H_2SO_4 , to destroy the fabric, filtered, rinsed in water containing soda and dried. After this the material was again finely ground then steamed as in method 1. and finally either rolled into sheets or brought into the market in the powdered state. The most important operation in both methods seems to be the steaming, whereby the article is de-vulcanized by the oxidation of the S to H_2SO_4 , which again in its turn becomes neutralized by the alkali added. The result of either method however is to give an inferior caoutchouc which is in not quite free from sulphur. A great number of new methods have been proposed for devulcanizing caoutchouc. Most of them make use of caustic alkaline solutions, lime &c. According to the English Pat. 4803 of 1901 old vulcanized caoutchouc is kneaded together till it is as thin as possible, and then boiled for some time in water with finely powdered and strongly heated lime or cement. The result being that the lime forms with the extracted sulphur a soluble acid sulphate. After being boiled, the caoutchouc is washed and rolled, and can then be again vulcanised. According to the Swedish Pat. 14138 (1900) the India rubber articles should be cut into small pieces and treated with warmed naphthalene or some other solid hydrocarbon or their derivatives. When the mixture is sufficiently cool, alkaline alcohol, or some other suitable alkaline solvent, is allowed to act upon it until the pure caoutchouc remains behind. The Germ. Pat. 154542 employs as solvent, commercial carbolic acid, with which the vulcanized rubber is boiled *in vacuo*. According to the Germ. Pat. 135054 the India rubber fragments are spread out in thin layers and allowed to lie for a long time in a vacuum, whereby the greater part of the sulphur is volatilized. The Danish Pat. 6648 (1903) aims at effecting the recovery by treatment with powdered carbide, in the presence of steam, damp air or water. This is carried out more readily under pressure. THEILGAARD's process, Swedish Pat. 18979 of 1904, seems to differ from the other methods given, in that the free sulphur of the vulcanised refuse is extracted by a neutral sulphite solution.

These examples will be sufficient here; it may be added however, that the most varied and unsuitable substances and methods have been both proposed and patented for de-vulcanizing rubber. It must be emphasised that all the methods which depend on the effect of solvents or steam, do not treat of the actual de-vulcanization, but principally aim at restoring the hardened caoutchouc to the state of a plastic mass. This mass can be further vulcanised, for soft rubber is not a saturated product. By increased saturation with S the rubber indeed gains in resistance to chemical action, which explains the fact that articles made of regenerated rubber are more durable than those made from the natural product.

Caoutchouc substitutes. There are two kinds of caoutchouc substitutes, namely the white and the brown or black variety. The white substitute is obtained by the action of chloride of sulphur on fatty oils, particularly on

rape seed oil in the form of a light yellow to pure white elastic substance of loose crumbly consistency. The process in the formation of this product is similar to that of the vulcanization of caoutchouc with chloride of sulphur, that is, addition products of the fatty oils with chloride of sulphur are formed, which contain 6—8 % of S and a similar quantity of Cl. They are almost insoluble in alcohol and other organic solvents, but become saponified by alcoholic caustic alkali with separation of the Cl.

The brown or black varieties are obtained by treating fatty oils with sulphur at a high temperature. Thus they correspond to caoutchouc vulcanised with sulphur, and contain no chlorine. A better product is obtained if drying oils are used, which are oxidized before treatment with sulphur, by warming in the air. Rape seed oil for instance, is kept boiling by means of steam for two hours, cooled and oxidized by blowing air through it for 36 hours, then treated with 2 % sulphur and kept at 140° for two hours. 1 percent of sulphur is then added and it is again heated to 150° till it begins to "rise". The brown substitute comes into the market as elastic sheets, in pieces, or as ground powder of a yellowish-brown or red-brown colour. The content of sulphur varies between 4 and 20 percent. These substitutes are almost insoluble in organic solvents, but they dissolve in alcoholic alkali with formation of salts of the sulphuretted fatty acids. Caoutchouc substitutes are artificially made by various other methods, for instance by the electrolytic oxidation of acidified cod liver oil (Germ. Pat. 125314). Further there exists, according to the Amer. Pat. 685038, a method for the production of a caoutchouc-like substance, by pressing the stems of *CHRYSOTHAMNUS* or *BEGELOVIA* and then treating the expressed juice with CS_2 in a closed vessel at a temperature of 40° C. The fluid is then drawn off, and the volatile part distilled off, when the gum remains behind. After washing it forms an elastic, flexible caoutchouc-like substance. One of the newest methods, that given in the Germ. Pat. 160120, appears rather difficult to carry out. The instructions are to take a solution of amber-colloid in castor oil and to heat it with sulphur to 180°. After cooling, ozone is led in until the whole has become tough, and finally, in presence of benzene and calcium carbonate, chloride of sulphur is allowed to act upon it, the whole being strongly cooled.

Many attempts have been made to prepare rubber-like substances from glue and similar materials e. g. French Pat. 364075 and 369719. The product prepared according to the latter patent is sold under the name of Zakin rubber. It has only a slight resemblance to rubber and is not proof against the action of water. The method is as follows. Adhesive substances are dissolved in water with the addition of "filling" materials and hygroscopic bodies such as glycerine $CaCl_2$, $MgCl_2$, &c. To this solution is added a mixture or solution of colouring matters in paraffin oil, mineral oil, fats, &c. Chromates or other oxidizing agents are added in order to convert the whole into a hard mass.

The use of rubber substitutes has recently greatly declined on account of the introduction of various processes for de-vulcanizing old rubber (see CAOUTCHOUC).

For a long time HARRIES has been engaged in trying to prepare synthetic rubber, but no definite results are yet to hand. WEBER, too, at the time of his death, seemed to be on the point of succeeding in a similar attempt.

Caramel (BURNT SUGAR) is made from glucose or starch syrup melted in iron vessels with constant stirring. Soda or quick lime (1—3 %) is often added. The higher the temperature while burning the better the product dissolves in spirits of wine, but the temperature must on no account exceed 200°. After the melting process is finished 50 % of hot water is added before filtering through charcoal. After cooling, the colouring matter, the caramel, forms a brown tough syrupy mass which on being dissolved in H_2O or alcohol

becomes of a deep yellow brown colour, on account of which it is much used for colouring liqueurs vinegar spirits, beer, &c.

The so called „COFFEE ESSENCE” is nothing more than caramel. Compare COFFEE ESSENCE.

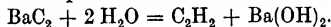
Caramel:

E. S. Spencer Ltd., Drummond works, Drummond Road, London S.E.

Carbides, METALLIC CARBIDES. The compounds of metals with carbon are usually classed with the alloys on account of the extremely varied proportions in which the constituents are combined. Most of the carbides are formed only at a very high temperature. The temperature of the electric arc is usually necessary and the operation is therefore carried out in electric furnaces.

1. **BARIUM CARBIDE** BaC_2 . According to the Germ. Pat. 117920, BaSO_4 is first reduced at a red heat with excess of coke to BaS , this is then powdered and melted, and mixed with iron filings in an electric furnace. The formation of the carbide is considerably facilitated by the addition of metallic iron which combines with the sulphur to form ferrous sulphide. The BaC_2 is decomposed with water for the preparation of acetylene and crystallized barium hydrate.

The decomposition takes place in accordance with the following equation:—



2. **BORON CARBIDE** B_6C , obtained from boron compounds and carbon in electric furnaces. It is best obtained from free B and C in presence of Cu. The Cu is dissolved from the fused mass with HNO_3 whereupon the B_6C remains as shining black crystals, which possess a great degree of hardness, greater than that of carborundum. This extraordinary degree of hardness may make boron carbide an article of considerable practical importance. Germ. Pat. 152501 describes a method for making this carbide by strongly heating quartz with coke, clay, calcium borate, boric acid and common salt.

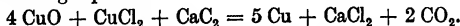
Other carbides exist but are as yet of no commercial importance.

3. **CALCIUM CARBIDE**, usually called simply CARBIDE, CaC_2 ; is obtained from dried, powdered coke or charcoal, by heating with quick-lime in electric furnaces of special construction. These are the so-called CARBIDE FURNACES. It is of importance not only that the ingredients should be in the right proportion but also that they should be thoroughly well mixed.

In furnaces for intermittent work the reaction is carried out in a carbon crucible connected with a conductor which forms one electrode.

The other electrode is a carbon rod which is adjustable and projects into the crucible. The carbide furnaces for continuous production are much more economical. In these the fluid carbide is drawn off from below while the lime and coke are supplied from above. Since the temperature, not the electricity, is the effective factor in the formation of carbide, either constant or alternating currents can be used. It is not necessary to go into the details of the American Pat. 765838, or the French Pat. 332416. Both of these treat of the manufacture of carbides.

Calcium carbide is a hard, black or brown crystalline substance, which is insoluble in any solvent, but decomposes with H_2O in the cold with formation of acetylene. Compare ACETYLENE. Besides being employed for producing this gas, CaC_2 has of late been used as a reducing agent for metallic oxides, salts and ores. The chlorides are especially adapted for reduction in this manner. To the chlorides is added the oxide of the same or a similar metal to combine with the C. The reaction taking place in the case of Cu corresponds to the following equation



NaCl or the easily fusible mixture of KCl and NaCl serves as a flux. The chlorides must be absolutely free from water to prevent the decomposition

of the carbides in the cold. It is very easy to prepare Cu, Pb, Ag and Ni by this method. The FRANK process of obtaining nitrogen from the air seems to be of great importance in the carbide industry. Compare the articles on CALCIUM COMPOUNDS and CALCIUM CYANAMIDE.

Calcium carbonate:

Wesenfeld, Dicke & Cie., Barmen-R., Germany.

4. SILICON CARBIDE see CARBORUNDUM.

Carbodynamite, see DYNAMITE.

Carbohydrates. Organic compounds of the general formula $C_mH_nO_n$. The H and O are present in the proportion in which they occur in water. The following groups of carbohydrates are recognized:— MONO-SACCHARIDES $C_6H_{12}O_6$, DI-SACCHARIDES $C_{12}H_{22}O_{11}$ and POLY-SACCHARIDES $(C_6H_{10}O_5)_n$. To the mono-saccharides belong GRAPE SUGAR and FRUIT SUGAR, to the disaccharides CANE SUGAR, MILK SUGAR and MALT SUGAR. The poly-saccharides include STARCH, DEXTRINE and CELLULOSE.

Cf. CELLULOSE, DEXTRINE, FRUIT SUGAR, MILK SUGAR, INVERT SUGAR, STARCH, GLUCOSE, SUGAR and SUGAR MANUFACTURE.

Carbolchalk, see DISINFECTANTS.

Carbolic acid, see PHENOL.

Carbolineum is a mixture of heavy coal-tar oils which are treated with chlorine at a moderately high temperature with continual stirring. By this treatment the very unpleasant smell of the crude substance is removed. Carbolineum which is an excellent preservative for wood has a S. G. above 1.12; M. P. 295° . This substance usually contains also a small amount of zinc chloride.

Some preparations which are not treated with chlorine, and are made from less suitable tar oils are sold under the name of CARBOLINEUM.

Carbolineum:

C. A. Peters Ltd., Derby, London, Liverpool.

Carbolysin. Pastilles of phenol are sold under this name.

Analysis shows that they contain 51.8 % phenol, 2.74 % $NaHCO_3$, 46.06 % cream of tartar.

Carbon. C. atomic weight = 12.00. Pure carbon is found in nature in the crystalline state as DIAMOND and GRAPHITE (q. v.) in the amorphous state — more or less impure — as anthracite (90—95 % C.) coal (to 90 % C.), and as brown coal, lignite (to 70 % C.). Amorphous carbon is obtained by heating organic bodies in air-tight chambers. Compare also the article on DIAMONDS, ARTIFICIAL; GRAPHITE; COALS; COAL DUST; SOOT.

Electric Carbon:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Carbon dioxide. CO_2 . This acid is often obtained from the naturally occurring CO_2 of springs. In other cases it is either produced from carbonates or carbon. Of the carbonates $CaCO_3$ (lime stone, marble, chalk) and $MgCO_3$ (magnesite) are used, the former being decomposed with dilute HCl and the latter with dilute H_2SO_4 in specially adapted vessels. These safety vessels are covered with lead plates, or are made of stone. Sometimes they are of earthenware. The gas is purified with H_2O and washed in solutions of Na_2CO_3 , $FeSO_4$ and $KMnO_4$. Impure CO_2 is prepared by burning lime-stone. If during the burning, H_2O is introduced a red heat is all that is necessary. The materials for producing CO_2 from carbon must be pure. Gas-coke, or more rarely anthracite and wood-charcoal are used. The carbon is put in special ovens, burnt to

CO_2 though on account of the atmospheric N, the resulting gas contains only 15—17 % CO_2 . The CO_2 is forced into a cold solution of Na_2CO_3 or K_2CO_3 , whereby the carbonates are converted into bicarbonates while the other gases escape. The solution of bicarbonate is then pumped into a vessel where the bicarbonate is decomposed by heating to 100° , and the pure CO_2 is collected. According to a new method, now much employed, coke is burnt under steam boilers and the gases are conducted into the scrubbers (see GAS ILLUMINATING) through which flows a solution of caustic alkali. By this means the CO_2 is separated from the other gases which meet the current of liquid. The gases are absorbed by the solution and the CO_2 is forced back into the above mentioned vessel in which it is heated with regeneration of the CO_2 .

According to the Germ. Pat. 132623 and 135552 pure CO_2 and sodium sulphite are obtained from Na_2CO_3 by decomposing the Na_2CO_3 with a solution of sodium bisulphite, produced by saturating with the SO_2 -gas from pyrites ovens the neutral sulphite solution obtained as a by-product in this process. A portion of the neutral or acid sodium sulphites can be used for other purposes. The Germ. Pat. 138386 describes a method for the continuous production of pure CO_2 from carbonates of the alkaline earths. The carbonates are placed in air-tight vessels and the necessary heat is supplied by the circulation of pure CO_2 , or a mixture of CO_2 and steam free from air. These gases which serve as the heating agent are heated in a system of closed tubes which prevents their contamination by the fire gases. The tubes are connected on both sides with an oven filled with carbonates. The gases to be heated are repeatedly passed from these ovens, after separation of the CO_2 from the carbonate, and again led back so that the cycle is continuous.

According to the English Pat. 14112 (1903) poor phosphates containing CaCO_3 are first heated to a red heat to destroy the organic matter, and then dissolved in various mineral acids. The CO_2 is thus obtained and dicalcium phosphate is separated from the filtered liquid by precipitation. The Ca is then precipitated with H_2SO_4 (as CaSO_4) and the filtrate from this, containing mineral acids, serves for the treatment of fresh phosphates.

According to the Amer. Pat. 774092 coal is calcined in a closed space and the heat of combustion is employed to heat a solution of an alkali bicarbonate and so to expel pure CO_2 .

The crude CO_2 from the coal is washed with H_2O and then conducted into a solution of an alkali carbonate until the latter is converted into bicarbonate. When this occurs and when the solution obtained by the heat of combustion of the coal is converted into normal carbonate, the current of acid gases is diverted so that the process is continuous.

For transport the CO_2 is liquefied by the use of suitable compressors at 50—60 atm. and then compressed farther during cooling.

According to a patented process, liquid CO_2 can be made directly from the gases obtained during the combustion of coal. The liquid carbonic acid is transported either in wrought iron or (usually) in seamless steel cylinders. The Germ. Pat. 157403 deals with the storage and transport of CO_2 in a solid form. This does away with the necessity for steel vessels as only air-tight receptacles, which are cooled to below -79° are needed. The cooling is carried out by surrounding the receptacle with a suitable cooling-mixture (e. g. ether and liquid CO_2). The escaping gases are drawn off into a compressor and after condensation are forced back again into the cooling chamber.

CO_2 is a colourless gas with a sharp taste and smell S. G. 1.524 (at 0°). The critical temperature is $+30.9^\circ$ at which temperature the CO_2 can be liquefied under a pressure of 73.6 atm. At 0° it is liquefied by a pressure of 36 atm. Liquid CO_2 is a colourless mobile fluid S. G. 0.947 (at 0°). Its boiling point is -78.2° . By evaporating liquid CO_2 it can be

obtained in the form of a snow-like substance. CO_2 -gas is incombustible and will not support combustion; it causes asphyxia.

1 vol. H_2O dissolves at 0° 1.7967 vol. of CO_2 . It is used in the sugar industry. It is also used for making bicarbonates and carbonate of lead. Further it is employed in the ammonia-soda process. Liquid CO_2 is used in the manufacture of mineral waters, effervescent lemonades, &c. and for carbonating beer. Carbonic acid is employed in many other ways and has lately been introduced for the purpose of hardening cast steel. It is also employed for fire-extinguishing purposes.

Carbonic acid. Machines, Developers, Apparatus for Determination:

Willy Manger, Dresden, Germany.

Carbon disulphide, CS_2 . By far the greatest quantity of this substance is still made by the old process, i. e. by passing sulphur vapour over coke heated to a dull red heat. It is usually made by heating carbon (as a rule charcoal) in cylindrical vertical retorts of cast iron and gradually introducing the S through a porcelain tube. The tube reaches almost to the bottom of the retort. The S melts, is vaporized and combines with the glowing carbon, in accordance with the equation, $\text{C} + \text{S}_2 = \text{CS}_2$. The volatile CS_2 mixed with sulphur vapour is condensed in suitable cooling apparatus and purified by distillation. Impurities, such as the H_2S originating from the H present in the charcoal are removed by washing the CS_2 with limewater before distillation. In the distillation vessel the CS_2 is mixed with a colourless fatty oil, a little H_2O is added and a small amount of lead acetate solution. It is then distilled from a water bath.

CS_2 can also be obtained at a red heat from pyrites FeS_2 , from antimony sulphide or zinc blende by heating with C. $2\text{FeS}_2 + \text{C} = 2\text{FeS} + \text{CS}_2$. Also by leading SO_2 over red hot carbon. In practice, these processes are, however very seldom carried out. On the other hand the manufacture of CS_2 in electric furnaces is rapidly becoming important. TAYLOR's process, Amer. Pat. 688364 and TAYLOR's furnaces have quite changed the method of manufacture of CS_2 in America. The furnace consists principally of two upright concentric brickwork cylinders, containing carbon, while the interstices are filled with sulphur. In the lower part are two carbon electrodes, each having a surface of 20 square inches, which heat and decompose the mixture as it falls. The sulphur vapours combine with the red hot carbon. The wear of the carbon electrodes is said to be small. The Germ. Pat. 150826 and 150980 which deal with TAYLOR's process, say that the sulphur and the carbon are introduced into the furnace continuously and in small amounts. At the same time they are so separated, that the liquid non-conducting S touches the electrodes, and on rising more or less surrounds them and thereby regulates the arc. As soon as the S approaches the hot zone, the fluid mass rises to the surface in the form of vapour. The vapours pass through the carbon lying above and combine with this to form CS_2 . The CS_2 vapours are led away and condensed. The English Pat. 13466 (1903) describes a method for obtaining CS_2 from coal gas, heating gas, &c. by washing the gases with an oil which swims on the surface of the liquid obtained by the dry distillation of waste liquors. This oil, which can be dried by suitable means, absorbs large quantities of CS_2 . The oil can be purified for repeated use by heating with or without the simultaneous introduction of steam.

Crude or imperfectly purified CS_2 is a pale yellow, extremely unpleasant smelling liquid. S. G. 1.293. In a pure state however it forms a mobile strongly refracting liquid, clear like water with a strong smell resembling that of chloroform. S. G. 1.2684, B. P. 46.5° . It evaporates at the ordinary temperature, is inflammable and burns with a blue flame. When mixed with air the vapours are very explosive. It dissolves to an extent of less than 1 %

in H_2O , can be mixed in all proportions with alcohol, ether, chloroform, benzene, &c., and is an excellent solvent for fats, oils, resins, waxes, camphor, tar, caoutchouc, gutta percha, iodine, phosphorus and sulphur.

It serves for the extraction of vegetables and of bones, for removing fat from animal and vegetable fibres, for vulcanising caoutchouc, for the purification of tallow, stearine, paraffin and wax for filling hollow prisms, for the manufacture of Carbon tetrachloride (q. v.), and for many other purposes. It is an excellent remedy for diseases of the vine, and is very effective in destroying the vine louse. For the last named purpose it is often used in the form of potassium xanthate $\text{CS}(\text{OC}_2\text{H}_5)_2\text{SK}$. This substance is formed by the treatment of an alcoholic solution of KOH with CS_2 .

Carbon monoxide CO . Colourless gas which in the pure state is odourless. S. G. 0.9674, B. P. — 190° , M. P. — 207° . It dissolves slightly in H_2O , burns with a blue flame, and when mixed with O is violently explosive. It is an extremely poisonous gas and forms the harmful part of choke-damp. For tests for the presence of carbonic oxide see GAS ANALYSIS. It is artificially obtained, in the form of a mixture of CO and H for heating and indirectly for lighting, by passing steam over red hot coke. According to Eng. Pat. 3347 (1903) a mixture of lime stone and coke is heated in a lime kiln. The gases evolved rich in CO_2 , are passed over glowing coke when CO is formed. After cooling, the coke is again brought to white heat by blowing air trough the oven. These operations are repeated alternately. Compare also the articles on PRODUCER GAS and WATER GAS.

Carbon tetrachloride CCl_4 . This substance is obtained from carbon bisulphide by passing Cl and CS_2 vapour through a red hot porcelain tube. A more simple process is to pass dry Cl into CS_2 after a little iodine has been dissolved in the latter. The reaction corresponds to the equation $\text{CS}_2 + 6\text{Cl} = \text{CCl}_4 + \text{S}_2\text{Cl}_2$. It is then distilled: CCl_4 first passes over while the less volatile chloride of sulphur remains behind. The CCl_4 is purified by fractional distillation, washing with alkali and a final distillation. According to Germ. Pat. 72999 and the Eng. Pat. 19628 carbon disulphide is heated with S_2Cl_2 with the addition of a metallic powder, iron being the best. According to the equation $\text{CS}_2 + 2\text{S}_2\text{Cl}_2 = \text{CCl}_4 + 6\text{S}$ carbon tetrachloride and sulphur are formed, so that as a secondary product sulphur is obtained which can be employed again for the preparation of carbon disulphide required instead as in the older method of chloride of sulphur, which it is impossible to make use of in large quantities. The purification of the carbon tetrachloride thus obtained is carried out as described above.

A newer method of procedure Eng. Pat. 25688 (1901) has been given by COMBES. This method is carried out by the action of chloride of sulphur on red hot carbon, best in an atmosphere of chlorine. If the work is carried out without chlorine CS_2 is also formed which as is known can be converted into CCl_4 . See above. If a chlorine current be employed for the reaction, chloride of sulphur is continuously formed which in turn takes part in the process.

According to the French. Pat. 327322 Cl and CS_2 vapours are passed over some "contact substance" which is insoluble in CCl_4 (e. g. asbestos covered with MnCl_2), or S_2Cl_2 , which in this process is formed simultaneously with CCl_4 is treated with CS_2 vapours in presence of metallic sulphides, e. g. ferrous sulphide.

An improvement in the continuous method for preparing CCl_4 is protected by the French. Pat. 355423.

According to Amer. Pat. 737123 CCl_4 can also be obtained by heating a mixture of 1 part of coke, 4 pts of NaCl and 2 pts of quartz sand. According to Amer. Pat. 745637 a substance containing C and silicon chloride is heated in a dry and non-oxidizing atmosphere by electricity to a temper-

perature which is high enough to bring about the combination of the C with the Cl, e. g. $\text{CS}_2 + \text{SiCl}_4 = \text{CCl}_4 + \text{SiS}_2$. (By heating the SiS_2 with C, Si is simultaneously obtained.) A mixture of SiO_2 and an alkaline chloride forms SiCl_4 on heating: this can be mixed with a carbon compound and again heated.

According to Amer. Pat. 794789 double the theoretical quantity of sulphur chloride is allowed to act upon CS_2 in presence of aluminium amalgam for the purpose of obtaining CCl_4 .

The Amer. Pat. 794970 treats of the purification of CCl_4 . The sulphur chloride is removed in the form of a thiocarbonate by adding a soluble sulphide of the alkalis or alkaline earths.

According to French. Pat. 357781 the CCl_4 may be separated from the S_2Cl_2 by washing with hot alkalies. The latter compound is thus decomposed.

It is a heavy colourless liquid which smells like chloroform. S. G. 1.629, B. P. 77°. It is an excellent solvent and extracting agent, which is beginning to replace chloroform for many purposes. As it is almost impossible to ignite it, it is of increasing importance in the dyeing industry, in chemical cleaning establishments, and most of all as a substitute for benzene for cleaning woollen goods since the latter, still so much in use, is highly inflammable and consequently extremely dangerous. Carbon tetrachloride dissolves in the cold a number of hard and soft resins such as for instance benzoin (siamese), dammar, elemi, mastic &c. When warm the solvent qualities are of course increased. The various kinds of shellac, such as button lac, AC granate ruby, orange and bleached lac, only dissolve in small quantities in pure carbon tetrachloride, while a mixture of 40 pts by weight of this substance with 30 pts by weight of alcohol dissolve about 25 % of the above materials at a moderate temperature.

Sandarac and sumatra benzoin which are but slightly soluble in pure carbon tetrachloride dissolve readily in a mixture of 90 g of this substance and 10 g of alcohol, or in 80 g of carbon tetrachloride and 20 g of alcohol; copals, on the other hand, only dissolve very slightly either in the pure substance or in the mixture with alcohol. BENZINOFORM has been adopted as a registered name for carbon tetrachloride.

Germ. Pat. 169930 has for its object the making miscible of $\text{CCl}_4 + \text{H}_2\text{O}$. With sulphonated oils, e. g. Turkey red oil (and also with the gelatinous soap obtained from sulphonated castor oil according to Germ. Pat. 113433) it forms a homogeneous mass which is miscible in all proportions with water and so can be used for many industrial purposes.

Carbon tetrachloride:

Domeier & Co. Ltd., 20 Harp Lane, London E.C.

Carbonates, see under the various metals in question.

Carbonic acid, see CARBON DIOXIDE.

Carbonic acid Waters see MINERAL WATERS.

Carbonite, see SAFETY EXPLOSIVES.

Carbonization, see WOOL.

Carborundum. Silicon carbide SiC is formed according to the equation $\text{SiO}_2 + 3\text{C} = \text{SiC} + 2\text{CO}$. It is made by fusing 100 pts of sand with equal parts of coke or charcoal and a little common salt in an electric furnace. The NaCl has in this case only a mechanical effect. The materials used must be as pure as possible and great care must be taken in the mixing. The product of the reaction must be broken up after cooling and the shining green carborundum crystalline fragments sorted out by hand.

These fragments are then powdered, treated first with H_2SO_4 and then with NaOH . After this the substance is washed, burnt at red heat and treated

with HF. The purified product is again powdered, moistened, separated into various degrees of fineness and finally dried. For making polishing wheels, the carborundum powder is mixed with some cementing substance which sinters on burning. The mass is then moulded by hydraulic pressure and burnt in clay crucibles. The articles are of a green colour and are of great value for polishing when precision is required, for grinding, on account of their great hardness (9—10 degrees of hardness) and durability. Of late also SiC has been employed for reducing metallic oxides, salt sand ores. This is carried out in the same way as described under CALCIUM CARBIDE in the article on CARBIDES.

Carboys.

E. Baffitt & Co. Ltd., Castleford Yorks.

Cardboard. **Pasteboard.** This name is applied to sheets of paper substance with a thickness of from 0.5—5.0 mm. The manufacture of cardboard can be carried out in various ways. One method is to pour the paper pulp on to wire frames from which the water trickles away. This process however, which is the same as that for making hand-made paper yields a very second-rate quality of cardboard as there is only a very loose connection of the fibres. For this reason the better sorts are made by the following method. Ready formed leaves of paper, quite freshly made and of usual thickness are laid one upon another while still damp and firmly pressed together. This kind of cardboard is termed couched pasteboard to distinguish it from the hand made.

The best kind is the carton pasteboard, cardboard proper, which is made by pasting finished and dried leaves of paper one over another till the requisite thickness is acquired. Each of the leaves is cut to fit the under one and then pasted over separately.

Glazed cardboard is made by laying couch pasteboard filled with china clay or barium sulphate pasted into thin woven material.

Roofing pasteboard, tar pasteboard or gravel pasteboard (also called shingle pasteboard) is made by mixing stones shingle or gravel or coal tar in the pulp before pouring it on to the form. Sometimes also common pasteboard is soaked in tar.

Carton pierre for Roofing. This product is made either by mixing paper pulp with asphalt, coal-tar or brown coal tar, lignite, or by impregnation of the common pasteboard sheets with boiling asphalt. See also CARDBOARD.

Cardol, see ACAJOU BALSAM.

Carlsbad salts (artificial). Official mixture: 45 pts anhydrous sodium sulphate, 18 pts sodium chloride, 36 pts sodium bicarbonate.

Carmine, see COCHINEAL.

Carnallite, see ABRAUM SALTS.

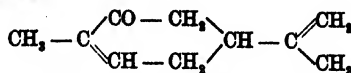
Carnauba wax, see WAXES, VEGETABLE.

Caro's reagent, see REAGENTS.

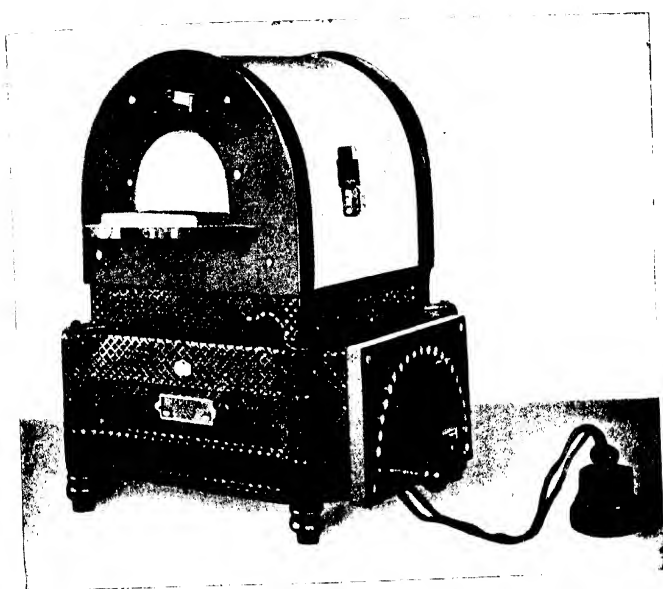
Caraway oil. Essential oil obtained from the seeds of *Carum carvi* S. G. 0.905—0.915. Contains limonene (35—55%) and carvone (45—65%) $\alpha_D^{20} = +75$ to 85° .

Carthamin, see SAFFLOWER.

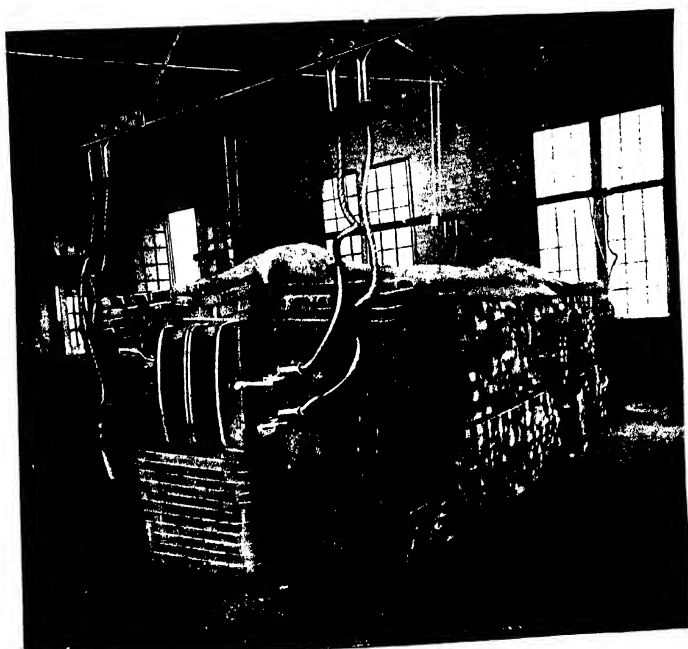
Carvone



Is present to the extent of 50 % in oil of caraway and 30 % in oil of dill. It is prepared by distilling oil of caraway, dissolving the fraction coming over above 20° in alcohol, and precipitating the sulphuretted hydrogen com-



ELECTRIC MUFFLE FURNACE (J. J. Griffin & Sons, Ltd., London)



CARBORUNDUM FURNACE

pound by means of H_2S in presence of NH_3 . The carvone is recovered by distillation with KOH .

Caseine. Has the same percentage of elementary constituent as egg-albumen but contain in addition 0.85 % P combined in a salt-like manner.

Caseine is obtained from cows' milk by diluting strongly with H_2O and then treating with acetic acid. The solid after being washed is dissolved in very dilute NH_3 or Na_2CO_3 , separated by filtration from undissolved fat and nucleins and reprecipitated with dilute acetic acid. The last traces of the milk fat are extracted with alcohol and ether after which the preparation is dried *in vacuo*.

Many processes have been suggested for the technical preparation of this substance, of which some have been patented. They all aim at cheap production. For instance according to Germ. Pat. 135350 the caseine is first precipitated from the skimmed milk with H_2SO_4 . This acid is cheap, but gives a yellowish product. If however the caseine thus obtained is dissolved in sodium bicarbonate solution and then reprecipitated with acetic acid, a very pure product is obtained.

The Germ. Pat. 135745 endeavours to obtain a non-fatty caseine without the use of ether-alcohol. The milk from which the cream has been removed by the usual centrifugal method, contains at least 0.2 % of fat and yields a caseine with 6—8 % fat. According to the patent in question, the skimmed milk is mixed with alkali and slightly warmed, when the fat is removed by centrifuging, and the caseine is then precipitated by acid in the usual way.

The substance thus obtained is sufficiently free from fat for most purposes. The Amer. Pat. 745097 is essentially the same.

The Germ. Pat. 152380 and 152450 treat of the manufacture of a caseine free from water. The caseine is combined with the alkaline salts, of glycerine phosphoric acid in which oleic acid is substituted or with alkaline salts of phosphoric acid in which hexite is substituted. The Amer. Pat. 765898 also treats of the manufacture of soluble caseine, while the Eng. Pat. 2949 (1903) gives a method for obtaining a suitable solvent.

According to the Amer. Pat. 750048 an oxidized caseine can be obtained by submitting caseine to the action of a solution of ammonium persulphate.

Other processes for the manufacture of caseine and caseine preparations need not be here mentioned.

Caseine is a white loose powder, slightly soluble in H_2O more so in hot alcohol. A combination of caseine with Na , is soluble in H_2O . Caseine is used for making colours, (see CASEINE COLOURS), and porcelain cement. It is also sometimes made use of as an article of nourishment. Compare MILK PREPARATIONS.

Germ. Pat. 161842 describes the production of a caseine product containing silicic acid which can replace eggalbumen for technical purposes such as the printing of materials. The process given is as follows. The caseine is transformed by heating with a dilute solution of ammonia into an alkaline albuminate. Potassium or sodium silicate is added and the mixture is decomposed by some suitable acid, such as phosphoric or acetic acid, till the whole, which at first solidifies again becomes a thin fluid.

According to Germ. Pat. 184300 the casein is precipitated from milk by SO_2 . The milk is warmed to 50—70° and the gas led in to it in a thin steam. The process is complete in a few minutes. The process seems to be a good one since the time taken is so short that there is no danger of inversion occurring.

Caseine colours. Are colours for painting in which the cementing substance consists of curds, quick lime and water; sometimes the caseine colours are also mixed with linseed oil varnish. Recently commercial caseine has been used instead of curds. See CASEINE. The caseine colours have proved of service

in the painting of the fronts of houses and for similar purposes, as they wear well even when exposed to the atmospheric agencies. As however in time they become influenced by the carbonic acid in the air and thus lose their weather proof qualities, they must be kept in tin cans hermetically sealed. The colours are made as follows. 200 parts of caseine are thoroughly mixed with 40 parts of powdered quick lime, and the colouring matter added, until a thick paste is obtained. This paste is then finely ground in a colour mill. It is then packed in tin cans of $\frac{1}{2}$, 1, $2\frac{1}{2}$, 5 and 10 kg and hermetically sealed. The following colouring matters may be mentioned as suitable. **WHITES:** zinc white, lithopone, china clay, and heavy spar (barytes). **YELLOWs:** ochre in all shades, Indian yellow and Naples yellow. **BROWNS:** Sienna and burnt Sienna, umber (raw and burnt), Cassel brown, Cologne brown, VAN DYCK brown, and brown stone. **BLACKs:** ivory black, Frankfort black, amp black. **REDs:** red leads, Venetian red, English red, caput mortuum and Indian red. **BLUEs:** ultramarine, cobalt blue, smalt or azure blue and mountain blue. **GREENs:** cobalt green, green earth and Guignet green.

According to the Germ. Pat. 142940 caseine quite free from fat is mixed with formaldehyde or carbolic acid or some other antiseptic and worked down with water to a thin liquid, which is then thoroughly mixed with an equal quantity of cement. As soon as the heavier parts have settled the remainder of the fluid forms a good stable medium for the most sensitive colours.

The caseine colours give stable colours with a matte surface. They are not expensive. The only disadvantage is that mineral pigments alone can be made use of in their manufacture.

Caseine apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Cassel yellow see LEAD COLOURS.

Cassia, oil of see OIL OF CINNAMON.

Cassius, purple of see "GOLD COLOURS".

Castor oil. An oil obtained from the seeds of the Palma Christi, *Ricinus communis*. The best kinds are prepared by crushing the seeds, warming to 80° and pressing. Inferior kinds are also prepared by a second and third pressing and also by extraction with carbon bisulphide.

In order to refine the oil it is heated with an equal volume of water to boiling and decolourised with animal charcoal. The same object is attained by exposure to sunlight, but in presence of air it is apt to become rancid. According to Germ. Pat. 144180 castor oil may be purified by washing with a 50 % alcoholic solution of Na_2CO_3 . In this way the castor oil should separate quite clear and the impurities should remain in the alcoholic soap solution. Aqueous alkaline solutions cannot be used because the soap then remains dissolved in the oil.

A pale yellowish non-drying oil which is viscid and has a mild taste, with a bitter after-taste. It becomes cloudy at 0° and solidifies to a buttery-like mass at -18°. S. G. 0.915 at 15°. Saponification number 180, Iodine number 83 to 94.

It is used in medicine, in the manufacture of soap, as an illuminant, and as a cosmetic. After saponification it is also employed as a mordant in dyeing. See OIL MORDANTS.

According to the Germ. Pat. 104499 a product known as florizine is prepared from castor oil by distilling the latter in retorts until 5-10 % has passed over. A yellowish-brown oil with a green fluorescence is then obtained which is as viscous as castor oil but which has quite different solubilities. It is soluble in all proportions in mineral oils at the ordinary temperatures,

a property not possessed by the original oil. It is further miscible to almost any extent in ceresine and vaseline and almost insoluble in alcohol and acetic acid. To attain this solubility is the object of the above method.

This substance is also known by the name derizine.

The Germ. Pat. 150554 and 152596 protect the method of manufacture of a castor oil preparation in the form of a powder intended for medicinal use. The castor oil is emulsified with separated milk or with a mixture of caseine and milk-sugar, and the emulsion so obtained evaporated to dryness.

The Germ. Pat. 156999 also has for its object the preparation of a solid form of castor oil. According to this method the oil is mixed with MgO or $MgCO_3$ and H_2O and allowed to evaporate in the air. The addition of gum arabic is also suggested, but the uses of the powder so obtained are not specified.

Catalysis. By this term are understood certain processes in which a possible reaction is accelerated by the presence of an agent which itself remains unchanged. This agent is called a catalyst. Catalytic processes are well known and of various kinds. From a lecture given by BODLÄNDER at the International Congress for Applied Chemistry, Berlin 1903, we quote the following list of inorganic catalyts which are of importance in chemical industry.

The sign“?” denotes that doubt is entertained as to whether the process is strictly catalytic.

Carriers of atmospheric oxygen.

Catalyst	Reaction
Platinum	H_2SO_4 manufacture.
“	Formaldehyde manufacture.
“	HNO_3 from NH_3 .
Carbon	Alcohol and water purification
HNO_3	Lead chamber Process.
“	Cyanide from thiocyanates.
“	Cl from HCl.
Copper compounds	Deacon's Process.
“	Formaldehyde
“	Methyl violet from Dimethylaniline
“	Cu SO_4 manufacture by means of SO_3 or SO_2
“	Ag extraction (Russel) (?)
Fe_2O_3	SO_3 manufacture
“	Sulphide roasting
“	Phthalic acid + benzoic acid from Naphthalene
“	Coal gas and water purification
Mn and Pb oxides	Linseed oil varnish
Compounds	SO_3 manufacture
CaO	PbO from PbS.

Carriers of oxygen (combined) other than the above

Catalyst	Source	Reaction
Vanadium chloride	CrO_3	Aniline black from Aniline.
“	Nitro benzene	Fuchsine manufacture.
Copper compounds	CrO_3	Aniline black from Aniline
“	Nitro benzene	Fuchsine manufacture
“	$KClO_3$	Methyl violet from Dimethyl aniline
$FeCl_3$	Nitro benzene	Fuchsine and Nigrosine manufacture.
Fe_2O_3	KNO_3	S. compounds (in NaOH).
Hg compounds	H_2SO_4	Kjeldahl's N determination.
“	“	Phthalic acid from naphthalene.
Oxalic acid	CrO_3	Discharging of Indigo.
Blücher.		10

Reduction (addition of Hydrogen).

Catalyst	Reaction
FeCl ₃	Aniline from nitrobenzene.
Iron	Addition of H to the unsaturated hydrocarbons.
Ni	Stearic acid from oleic acid.
Cu	Aniline from nitrobenzene.
I	Reduction in presence of P.
Other catalytic reactions cannot here be mentioned.	

Catatype. OSTWALD and GROSS thus designate a new method for copying photographs. In this process positive copies are obtained from negatives by effect of contact instead of light. This method is thus founded on the principle of catalysis (see this article). The process is carried out in various ways. For example, a common glass negative is rinsed with an ether solution of hydrogen peroxide and then pressed, after the ether has evaporated, in a copying frame with non-sensitized pigment paper, that is paper prepared with gelatine or gum and colouring matter only. The time required for the result is about 30 seconds. During this time an invisible positive of H_2O_2 has appeared on the negative in the following way. The hydrogen per-oxide is catalytically strongly affected by metals, e. g. by Ag, of which the glass negative is composed. The H_2O_2 therefore becomes decomposed with great rapidity after the evaporation of the ether in the places where silver is found i. e. the high lights, while on those places in the original where there is no Ag, i. e. the shadows, no decomposition takes place. In those places corresponding to the half tones, the extent of the decomposition depends on the depth of the shade, that is in proportion to the amount of Ag found there. The invisible H_2O_2 positive so obtained is transferred to the pigment paper by the pressure. To render it visible on the paper, the latter may be treated with solutions, of ferrous salts which in the parts covered with H_2O_2 will pass into ferric salts and thus render insoluble the gelatine or gum as in the bichromate-gelatine process.

The catatype picture can then be produced by washing with warm water in the usual way.

The quickness of the process, its great possibilities of application and the fact that it is independent of the action of light recommend its wide use.

For particulars see Germ. Pat. 147131, 157411 and 158368.

Catechine a colouring matter used as a substitute for catechu. It is a much faster dye than catechu itself and can stand exposure to light and air much better. It is three times as strong as gambier and is supplied in various shades from yellow brown to violet brown. It is used for dyeing cotton and for giving pure brown shades to sail-cloth, tents, fishing nets, &c.

Catechu. Compare TANNING MATERIALS. A distinction is made between brown catechu, also called Pegu catechu or simply Pegu, and yellow catechu also called Gambier catechu or simply GAMBIER.

The first mentioned catechu is the extract of the heart wood of the ACACIA CATECHU, and is made in India. It is obtained by soaking in cold water or by boiling in water and then evaporating to a paste which solidifies on cooling. It is a dark brown, brittle, astringent tasting substance, which partially dissolves in cold and completely in hot water. If the substance is treated with cold water the catechu-tannic acid (which is used for tanning) is dissolved while the catechine used for dyeing remains unaltered.

Gambier is the extract of the stalks and leaves of NAUCLEA (UNCARIA) GAMBIER, which is specially cultivated in Further India and Sumatra.

The parts of the plants are plucked twice or four times a year. They are then boiled in water for 5—6 hours and the extract evaporated to a syrup, when it is poured into wooden tubs or troughs to cool and solidity. When it has become quite firm the substance is cut into cubes or slices which are then allowed to dry. In Sumatra and Bitang sago starch is mixed with the gambier to render it harder. Cube gambier is generally brown outside and yellow towards the centre. When quite fresh however it is white. Its value is estimated by the amount of catechu tannic acid and catechin contents.

TEST. a) **PEGU CATECHU.** The ash contents should not exceed 4 per cent. The plant residue not more than 15 per cent. The amount of ash is determined by carbonizing slowly and then keeping at red heat until a constant weight is obtained. To determine the amount of plant residue the Pegu is boiled with ten times its quantity of alcohol and the residue dried at 100°. As a reaction for indentifying Pegu catechu, DIETERICH gives the following method. If Pegu catechu is treated with dilute alcohol and FeCl_3 solution, a green colour appears which rapidly passes into brown. When rendered alkaline, a precipitate is formed which turns a violet-blue. Pegu catechu however shows a fluorescence as is the case with gambier.

b) **GAMBIER.** The ash should at most amount to 5 per cent, the plant residue to not more than 15 per cent. The determination is carried out in the same way as is done for Pegu. DIETERICH gives the following method for identification: 3 g of gambier are treated with 25 ccm aqueous normal potassium hydroxide, and 100 ccm water, and 50 ccm benzine (S. G. 0.700 at 15° C.), and shaken for a time in a separating funnel. After the separation of the two layers, the benzine will show in the light an intense green fluorescence the intensity of which depends upon the length of time that the mixture stands. This is the so called gambier fluorescence. If the diluted alcoholic solution is treated with FeCl_3 solution, an intense and lasting green colour appears.

Caustic alkalies.

The caustic alkalies are described under the various metals.
For details of the electric method for obtaining caustic alkalies see the article on **CHLORINE-ALKALI PROCESS, ELECTROLYTIC.**

Caustic colours see **PRINTING OF TEXTILE FABRICS.**

Caustic lime see **LIME.**

Caustic lye see **POTASSIUM LYE** or **SODIUM LYE.**

Caustic soda, see **SODIUM HYDROXIDE.**

Caustics.

CAUSTIC VARNISH, ETCHING GROUND:

4 parts of asphalt, 1 part of black and 1 part of Burgundy pitch, 1 part of white wax,

or

5½ parts of Syrian asphalt, 3 parts of colophony, 9 parts of mastic.
18 parts of wax and 1½ parts of tallow.

The ingredients are melted together and well boiled. The etching ground is then put on to the hot metal.

CAUSTIC FLUIDS.

1. **FOR STEEL.** 1 part of nitric acid, 1 part of absolute alcohol, 4 parts of conc. acetic acid

or

2 parts of nitric acid and 1 part water.

2. FOR COPPER. 10 parts fuming HNO_3 , 70 parts of water and a solution of 2 parts of potassium chlorate in 20 parts of water,

or

40 parts of hydrochloric acid in 100 parts of water and a solution of 5 parts of potassium chlorate in 50 parts of water.

3. FOR SILVER and BRASS. Pure conc. nitric acid.

4. FOR ZINC. Dilute nitric acid.

5. FOR GOLD. Dilute aqua regia. Compare article AQUA REGIA.

6. FOR GLASS. Hydrofluoric acid. The vapour or steam is used for "grounding" glass (i. e. making it opaque), the aqueous solution for etching. Instead of hydrofluoric acid, ammonium fluoride or a mixture of fluor spar with sulphuric acid is used. A solution which gives good matte surfaces on glass is made by dissolving 250 g of double fluoride of potassium and 140 g of ammonium sulphate in a mixture of 250 g of hydrochloric acid and 1000 g of water.

ETCHING INK FOR GLASS. 30 g ammonium fluoride, 15 g distilled water, 6 g H_2SO_4 mixed together in a leaden bottle and heated to 40° .

After cooling, 5 g of concentrated hydrofluoric acid and 1 g of gum arabic (in solution) is added.

A steel pen or a quill can be used. The writing will look dead, dull, opaque
ETCHING MATERIAL FOR CHEMICAL DISCHARGE WORK ON GLASS. A very good medium is made by mixing a saturated solution of NH_4F in concentrated HF with MgCO_3 and dextrine. Method of making and proportions of contents are protected by the Germ. Pat. 148724.

ETCHING GROUND FOR GLASS. Wax, pure or mixed with turpentine oil.

7. FOR LITHOGRAPHIC STONES. Dilute HNO_3 or HCl , oxalic acid, or tartaric acid.

8. FOR AMBER, IVORY and BONE. Concentrated sulphuric acid.

9. FOR MARBLE. Dilute nitric acid.

10. FOR MOTHER-O'-PEARL. Concentrated sulphuric acid or concentrated nitric acid.

Cedar wood oil. Essential oil, produced either from the wood of the genuine cedar (*Cedrus Libani*) or from the Himalayan cedar (*Cedrus Deodara*), or on the other hand from the wood of the Virginian cedar (*Juniperus virginiana*) in each case by distillation with water. Most of the cedar wood oil sold comes from the latter tree, more properly called Virginian juniper.

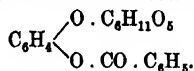
Colourless to pale yellow thinnish volatile, oil. S. G. (at 15°) 0.906 to 0.985. It is used for perfumes, and when evaporated as a medium between the front lens of the objective and the cover-glass in microscopic work. It is also used in the manufacture of soap, and in the industrial treatment of other oils.

Cellhorn see CELLULOID.

Celloidin is obtained from collodion (see this article) by precipitation of a collodion solution with water. As the greasy brownish substances remain in solution, the celloidin consists of pure nitro-cellulose. It is formed into cakes of about 200 g weight which harden into a horn-like, semi-transparent, milky substance.

Celloidin paper see PHOTOGRAPHIC PAPERS.

Cellotropine is obtained from the arbutine of the barberry by treatment with benzoyl chloride. Its constitution is monobenzoyl arbutin



It is a neutral, white crystalline powder, without taste or smell, M. P. 184.5°, soluble in alcohol or in boiling water. In cold water it is sparingly soluble. It is said to increase the natural protective substances of living organisms against infection and infectious diseases, and is therefore prescribed in cases of tuberculosis and scrofula. The dose is 0.3—0.5 g three times daily.

Cell substance see CELLULOSE.

Celluloid. When nitro-cellulose is pressed together with camphor under certain conditions the substance known as celluloid is obtained. The nitro-cellulose must for this purpose consist principally of di-nitro cellulose, see COLLODION. It is ground, the water removed and then rolled with 40—50 per cent of camphor. After this it is moulded in hydraulic presses, and heated to 80—130° under great pressure. After remaining in the press for some hours the celluloid is dried in a vacuum over fused CaCl_2 . If colouring matter is to be added, it is done when the nitro-cellulose is mixed with the camphor. Another process involves the use of methyl alcohol or ether. The work is in this case done in the cold, a solution of camphor is used and the substance thus obtained, which is plastic, is rolled out into sheets, which must again, after hardening, be treated in a warm state in hydraulic presses.

An extraordinary number of methods, most of which are patented, deal with the use of other substances in place of the camphor, which always emits a peculiar and characteristic odour. Some of the substances employed instead of camphor are, NAPHTHALENE, NITRO-NAPHTHALENE, NAPHTHYL ACETATE, PHOSPHORIC ACID ESTER and CARBONIC ACID ESTERS of PHENOL, CRESOL and NAPHTHOL, HALOGEN DERIVATIVES of the AROMATIC HYDROCARBONS, PHENOXYACETIC ACID and NAPHTHOXYACETIC ACID, ACETOCHLORHYDRINE, ACETINE, DI-NAPHTHYLKETONE, METHYL NAPHTHYLKETONE, NITRO-CELLULOSE and many others. The most important of the many methods are probably the following. Germ. Pat. 139589 in which the carbonates of the phenols, cresols and naphthols are suggested for this purpose, and Germ. Pat. 128120 and 144648 in which the phenol ester of phosphoric acid is used in the same way. Further the French Pat. 349970 which suggests the use of borneol in place of camphor should be noticed and the English Pat. 5280 (1904) which proposes ketones e.g. methyl ethyl ketone, methyl naphthyl ketone and others, for the above purpose.

Substances similar to celluloid are obtained by kneading together nitro-cellulose and caseine, and still better products are obtained according to Germ. Pat. 138783 and 139905 by treating a compound of caseine with a metallic oxide. Substances containing keratine (e.g. horn) have been suggested as suitable for celluloid manufacture. Some of these materials are, wool, claws, hoofs, horns, hair, feathers &c. According to Germ. Pat. 134314 these horny substances are cut up, dissolved in alkalies and precipitated by acids. The precipitate is then pressed and treated with gaseous or dissolved formaldehyde. It becomes hardened and unalterable in shape. The material is then said to form an excellent celluloid.

With regard to the ordinary camphor celluloid, it should be remarked, that attempts have been made for some time to substitute artificial camphor for the natural product (see CAMPHOR). The product obtained however, does not give satisfaction, and the non-success has in each case been traced back to impurities in the camphor. Recently CALLENBERG has discovered a process for refining artificial camphor, by which it is obtained as a crystal-clear substance, which also dissolves such nitrated cotton wools as are not acted upon by alcoholic solutions of natural camphor. The celluloid made in this way is very durable and when in addition to the camphor solution, a certain quantity of naphthalene is added, the product is neither inflammable nor explosive.

The following patents deal with the question of substituting camphor by other substances. Germ. Pat. 163668, 168497, 172941, 172966 (and addition 172997) 174259, 173020, 173796, 174914, 176474, 178133, 178778, 180126, 185808. French Pat. 368004, 372512. Amer. Pat. 831028.

To remove or to lessen the dangerous inflammability and explosiveness of celluloid, salts of aluminium, magnesium chloride, asbestos, naphthalene, &c. are added to the substance. On the subject of de-nitration of celluloid substances compare the articles on methods of De-NITRATION and SILK, ARTIFICIAL.

Germ. Pat. 162239 states that to decrease the inflammability of celluloid, it should be treated with cellulose acetate instead of with metallic salts, while the Germ. Pat. 149764 recommends the use of alkyl esters of silicic acid, such as amyl silicate and ethyl silicate for the same purpose. The other proposals which have been brought forward on the same subject can be passed over as less important, in some cases as being either too daring, or in others indeed, as quite senseless.

Celluloid is a substance which is semi-transparent to transparent and like horn. It is hard, elastic and very tough. The best kinds have no smell although inferior qualities smell of camphor. It can be welded and sized when warm, and is insoluble in water. On the other hand it readily explodes and burns with a smoky flame, emitting a smell of camphor. At a temperature of 125° it becomes plastic; at 140° it decomposes without explosion. Its many uses are well known.

According to Germ. Pat. 173990 a substitute for celluloid may be obtained by the action of formaldehyde on phenols (e. g. carbolic acid), or according to French Pat. 372018 from glue, castor oil and camphor with addition of a certain amount of celluloid previously prepared.

Celluloids:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Celluloid varnishes. Solutions of celluloid in ether, acetone or amyl acetate. It is a colourless clear fluid which leaves a thin celluloid coating on the surfaces painted with it. It keeps the metallic surfaces bright and shining as when new, and does not change the colour. Materials which absorb fluids, such as wood, leather, linen, &c. can be protected from external influences by celluloid varnish, without their appearance suffering in any way.

The celluloid varnishes are found on the market under various names, such as ZAPON VARNISH, BRASSOLINE, CRISTALLINE, and VICTORIA VARNISH. A mixture of celluloid varnish with powdered metal, bearing the name of GALVANO LAC can often take the place of electro-plating as a coating of this material is proof against atmospheric influences.

Lately zapon varnish has come much into use for preserving antique articles of value such as DOCUMENTS, COINS, MEDALS, SEALS, &c. (Cf. ANTIQUITIES).

Cellulose (CELL SUBSTANCE). Among the fibre substitutes used in the manufacture of paper, mechanical wood pulp and cellulose should be mentioned. For the former. Cf. WOOD. Cellulose differs from wood pulp in that it is a pure chemical product free from all impurities.

Cellulose is made from wood, straw, and also from esparto. The product however differs to some extent according to its origin. The most important variety is the wood cellulose.

The manufacture of wood pulp is now carried out according to one or other of three processes, viz. by the SODA PROCESS, the SULPHITE PROCESS or the ELECTRIC PROCESS.

1. In the soda process the wood, which is cut up into small pieces, is boiled for several hours in soda lye of 12° Bé. under a pressure of 6—8 atm.

The substance obtained after washing in water and mashing in a rag mill is a pale grey-coloured stuff, which after being put through a draining machine, comes out as a pulp. This is again disintegrated and cleaned in a bleaching rag mill. Cf. PAPER. Improvements on this system consist principally in treating the wood with steam and lye alternately, the temperature of the steam being raised and the lye made more and more concentrated. The work is carried out in boilers, 7—10 of which are connected in a series so that the steam and lye can be led from one into the other.

The Germ. Pat. 134263 gives a method for the manufacture of cellulose by the soda process from the refuse fibres of the skins of the cotton seed, which are waste products in the process of cotton manufacture.

These fibres remain on the seed shells after the cotton has passed through the ginning mill. Cf. COTTON and PLANT FIBRES. The fibres are first freed from gum, oil, and fatty impurities with naphtha, then boiled in weak caustic alkaline lye under pressure until they separate, after which the substance is washed.

2. The most important method for obtaining cellulose is by means of sulphurous acids or its salts. The different kinds of sulphite-cellulose are so obtained. The sulphite or bisulphite is prepared from natural calcium and magnesium carbonates, by the action of SO_2 gas in presence of H_2O , in suitable towers and specially-constructed chambers.

The boilers used in the sulphite process are made of enormous size, as the boiling has to go on for a long time. They are built to lie lengthways, are about 12 meters long, 4 m in diameter (internal) and contain 100 cubic meters of fine cut wood, and 60 cbm of lye. The boiler plates are 1.8—2 cm thick and lined with thin lead plating, burnt tiles or firebrick, to prevent destruction of the metal. The boiler is always heated with steam, either directly or indirectly. The movement of the lye is regulated by KÖRTING'S INJECTORS.

In this method too, the wood is cut in chips; the sulphite lye has usually a strength of 4—5° Bé. Steam is first turned on for a short time and when sufficient heat has been supplied, the lye is added and heated gradually until a pressure of 3 atm. (120°) is reached. The steaming process lasts from 10—15 hours, and the whole process of boiling 30—40 hours. The total time for heating, filling, cooling and emptying is about 90—100 hours.

The cellulose thus obtained, after being drained from the lye is washed in cold water. The amount of cellulose obtained is between 40—65 %.

3. KELLNER'S electric process, which is highly interesting, has of late become very popular. The wood is heated in brine and at the same time exposed to the influence of the electric current. The chlorine and hypochlorous acids dissolve the substances which fix and contaminate the cellulose.

In the course of the reaction the chlorine is converted into HCl , which then again unites with the sodium oxide separated at the cathode to form NaCl , so that the process is continuous, and very little salt is used. The two boilers in KELLNER'S apparatus (the anode boiler, and the cathode boiler) are heated indirectly by steam 126—128°. It has been proved more practical to carry on the work in open vessels without pressure. The current is usually reversed every quarter of an hour, which is necessary for the success of the process.

(Compare also the French Pat. 326313 and the Amer. Pat. 773941).

4. Although not new, BÜHLER'S PROCESS, Germ. Pat. 94467 has recently become of practical importance. For carrying out this method, the phenols and their derivatives, or tar oils containing phenol, are employed for decomposing the wood and separating the cellulose from the residue. The cellulose thus obtained is purified in beetling mills, washing troughs and pulp strainers, or in special apparatus for cellulose purification. After this it is sorted, and finally drained in drying machines. Very frequently before draining, the cellulose is bleached.

The cellulose on leaving the drying machine still contains about 50 % of water, which is reduced to 20 % or even 10 % by the use of drying cylinders.

Cellulose is not only obtained from wood, but also to a considerable extent from straw and some kinds of grass, e. g. Esparto grass. The grasses are treated by the soda process and the straw either with soda lye or with sulphite lye. The Germ. Pat. 151285 protects a method for disintegration of the fibres by means of a 1—3 % aqueous solution of SO_2 , into which NH_3 is previously conducted in such quantities as to completely neutralise the acid. The process is then carried on under a pressure of 4—10 atm.

Compare also the articles on NITRO-CELLULOSE, OXY-CELLULOSE, VISCOSE and CELLULOSE ESTERS.

Lately a method has been described for spinning the cellulose, so that woven articles of cellulose, made by different methods are no longer exactly a rarity. They are sold under various names e. g. Licella fabrics &c. For their preparation aqueous cellulose solutions are employed which are placed in an apparatus like that used in paper manufacture (slubbing machine). Channels are present by means of which the cellulose separates in flat ribbons. The latter are partially dried and spun, and from them tissues can be woven while yet in the moist state.

Wood pulp:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Cellulose esters. The esters of cellulose can be made in various ways. According to the Germ. Pat. 85329 cellulose acetate can be made by means of acetyl chloride and acetate of zinc; according to the Germ. Pat. 86368 by means of acetate of magnesium. The Germ. Pat. 105347 recommends an addition of nitrobenzene in the making of the ester. The reaction of the acetyl chloride or other acid chloride on cellulose, according to the Germ. Pat. 139669 is favourably influenced by the addition of pyridine or quinoline. In this case, the temperature of decomposition of the cellulose lies between 100° and 150°, according to the quantity of pyridine added. To accomplish rapid change, a solvent for the ester formed must be added. Acetone, nitrobenzene, naphthalene, &c. serve as solvents. The water (or the alcohol) is separated from the cellulose ester and, with the pyridine set free by the addition of chalk, can be recovered by distillation for further use. The Amer. Pat. 709922 states that the action of the acid chloride on the cellulose is promoted by an addition of aromatic sulphonic acids, such as phenol sulphonic acid, or naphthol sulphonic acid.

The Germ. Pat. 118538 describes a method for making cellulose acetate from hydro-cellulose by the action of acetic anhydride. In a variation of the process, protected by the French Pat. 319848 the cellulose is heated to 50° with glacial acetic acid containing a small quantity of H_2SO_4 , then cooled and the requisite amount of acetic anhydride is added to the hydro-cellulose so obtained. The process of the Germ. Pat. 153350 and 159524 as well as the Amer. Pat. 733729 are quite similar. In these methods the acetate of cellulose is obtained from cellulose, acetic anhydride, glacial acetic acid and sulphuric acid. In the French Pat. 316500 the H_2SO_4 is replaced by the various phosphoric acids, while in the French Pat. 324862, in place of the sulphuric acid, a mixture of phenol sulphonic acid and its sodium salt is used. The English Pat. 10243 (1903) adds small quantities of anhydrous inorganic acid chlorides, e. g. phosphorus oxychloride or phosphorus pentachloride to the mixture of glacial acetic acid and acetic anhydride, which serves to acetylate the dry cellulose fibres. The action is continued for 7—8 hours in a hot room at a temperature of about 55° after which it is stopped by adding water. This method produces a good soluble cellulose acetate. The same can be said of the product obtained according to the French Pat. 345764, in which dimethyl sulphate is added to

the mixture of glacial acetic acid and acetic anhydride. According to the French Pat. 347906 the acetylation is carried out by acetic anhydride in presence of sulphuric acid, phosphoric acid or an organic sulphonic acid, or the acetylating agent may be acetyl chloride in presence of sulphuric acid, phosphoric acid or some organic sulphonic acid. The acetylation takes place in an indifferent medium which prevents the acetyl cellulose from dissolving; benzene, ether, &c. may be used for this purpose. New patents connected with the acetylation of cellulose are:— Germ. Pat. 163316, 175379, 185837. French Pat. 368738, 368766, 371357, 371447, 373994. English Pat. 9998 (1905). Amer. Pat. 826229, 838350. According to the French Pat. 374370 the esterification is conducted in such a way that the original form of the cellulose is preserved. This can be attained by the addition of carbon tetrachloride. According to Germ. Pat. 180666 and 180667 the esters may be prepared by the action of organic acid anhydrides in presence of sulphuric acids. Cellulose acetate has proved an excellent material for the manufacture of artificial silk. The solution of the acetate is squirted into alcohol or a solution of ammonium chloride through very fine holes so that threads are formed. See SILK, ARTIFICIAL. On account of its great electric insulating power which is greater than that of silk, the silk made from cellulose acetate is used for making the coverings of insulated wires.

The Amer. Pat. 774713 and 774714 protect the manufacture of a substitute for horn, celluloid, &c., from cellulose acetate heated under pressure with thymol and chloroform, or with a phenol. Castor oil may also be added to the thymol. The French Pat. 341007 protects a new method of printing, in which cellulose acetates soluble in alcohol are employed as substitutes for thickening and fixative substances in making patterns for the printing of calico and other textiles.

HYDROCELLULOSE see the article on OXY-CELLULOSE.

The xanthate of cellulose is treated separately in the article on VISCOSÉ.

Cement. Hydraulic mortar, hydraulic lime. Cements, as opposed to ordinary mortar, are insoluble in, and harden under water, with which they combine chemically. Both artificial and natural cements are known. To the former belong the tuff-cements which are prepared from the volcanic tuffs by mixing with slaked lime. In place of the natural tuffs, artificially prepared silicates, such as blast-furnace slag, may be used.

Of greater importance are the artificial cements such as Roman and Portland cements. The former kind contains free lime and is obtained by heating marl not above its fusion point until most of the CO_2 is removed. When burnt, the substance takes the form of pieces as big as the fist. The process of burning is carried out continuously in furnaces in which the marl is placed with alternating layers of coke. The burnt Roman cement is broken and ground and is used either alone or in conjunction with fine-grained sand. On the addition of water it slowly sets with the development of a small amount of heat. The quality of the cement depends very largely upon the character of the substances from which it is prepared.

The most important kind of hydraulic mortar is Portland cement which is prepared by burning a mixture of lime and clay and powdering the product. The materials from which it is prepared are marls or chalk. The clay should be free from sand which may be removed by washing. According to this wet process the lime and clay are mixed with water in a stamping-mill fitted with a stirrer. The mass thus freed from impurities is placed in settling vessels, the water partially removed, and the thick paste made into bricks which are then burnt.

In the dry process the clay and chalk are ground separately and then mixed. The mixture is treated with water, thoroughly kneaded in a mill and then formed into bricks.

Finally a "half-wet" process may be mentioned in which the lime is washed and mixed with the dry clay (or *vice versa*). In this case, too, the mass is cast into bricks. The burning of the bricks is carried out either continuously or in ovens which are cooled periodically. In the latter kind layers of coke are introduced and the temperature is slowly raised until a white heat is obtained. The air enters from below and passes through the hot mixture.

In the ovens of the continuous type a great economy of fuel is effected.

The roasted cement is broken in mills and then ground to a fine powder. The properties depend upon the nature of the materials used in its preparation and upon the method of manufacture.

Recently blast-furnace slag has been recommended as a material eminently adapted for the preparation of Portland cement. It is in reality nothing but a cement poor in lime. Cements prepared from slag are known as slag cement, iron cement, or iron Portland cement.

The usual method of manufacture is to granulate the slag by allowing it to flow directly into cold water, drying and mixing with lime and finally grinding the whole to a powder. Portland cement may be used in place of the lime. The process is protected by the Germ. Pat. 151228 and English Pat. 18953 and 26683 (1902).

Other methods recommend heating a mixture of slag and lime (Germ. Pat. 151588). On the other hand the Germ. Pat. 153056 and 158363 recommend the use of slags containing a high proportion of lime so that no addition of the latter is necessary. Such slags are granulated in water, strongly heated and then ground.

According to Germ. Pat. 150769 a mixture of granulated slag and quicklime is heated with high-pressure steam and then ground. This is generally preceded by a previous drying which is carried out according to Germ. Pat. 159865 by first heating the slag in superheated steam and then mixing with the requisite amount of quicklime. A dry mixture is thus obtained which without any further drying is ground to powder in special mills.

Finally according to Germ. Pat. 162330 the fluid slag is quenched in a thin milk of lime without the addition of a further quantity of lime. The granulated mass is dried and ground in the usual manner.

The slag cement sets more slowly than the ordinary kinds, but is much harder. It has already been widely used and has undoubtedly a great future before it.

Mention must be made of magnesia cement (Sorel cement). It is prepared from slightly burnt dolomite which is treated with a solution of $MgCl_2$. It sets to a hard mass owing to the formation of magnesium oxychloride (with slight evolution of heat). In order to secure proper mixing the $MgCl_2$ solution is treated with thick gelatinous liquids such as solutions of glue, starch or dextrine, gelatinous silica (prepared by the addition of a solution of water-glass to $MgCl_2$) aluminium hydroxide, &c. Magnesia cement does not resist atmospheric influences, but is well adapted for cementing metallic objects.

According to BERKEL a magnesia cement can be prepared by acting on fluor-spar for some time with H_2SO_4 and then adding kieserite or a solution of $MgSO_4$ to the mixture. As soon as HF is evolved MgO is added; $CaSO_4$ and MgF_2 are formed which remain mixed with the $MgSO_4$. This kind of cement is not only very hard, but on account of the absence of magnesium oxychloride it is not readily attacked by water. The objects to be cemented are pressed together, dried in the air and finally gently heated.

For the preparation of weather-proof magnesia cement the Germ. Pat. 126178 recommends the use of baryta or witherite as a binding agent for the sulphuric acid derivatives found in the raw materials. Other methods are protected by Germ. Pat. 143933 and 151947. According to the latter, cement

can be prepared from burnt magnesia by partially neutralizing with gaseous HCl. The reverse process is adopted in Germ. Pat. 154976 and 169663 in which crystalline MgCl_2 is heated until not only is the water removed but HCl is also evolved. A mixture of MgO and MgCl_2 is obtained which is used as a cement. Other processes are described in Germ. Pat. 173120, 178013 and 186448.

Cephaldol. A substance prepared by the action of citric acid and H_2SO_4 on phenetidine with an addition of quinine and Na_2CO_3 . It is used as a mild antipyretic and antineuralgic. Yellowish-white bitter-tasting powder, readily soluble in alcohol, but with difficulty in water. Dose 0.2 to 1.0 grammes. Daily dose 3—5 grammes.

Ceramine Soap, see MEDICINAL SOAPS.

Ceramite. A solution of fluosilicates, used as a disinfectant, as a preservative for timber, and for hardening cements, &c.

Ceramite:

Humann & Teisler, Dohna, Bez. Dresden, Germany.

Ceramyl. A solution of hydrofluosilicic acid and its salts (chiefly of Fe and Al). S. G. 1.2528 (at 15°). It contains 19.84 % of free and combined hydrofluosilicic acid. It is very similar to MONTANINE (q. v.) and is used for the same purpose.

Ceresine. By this name ozokerite is sometimes known, though, generally speaking, the name is applied to a preparation of this substance (q. v.) The ceresine resembles in some respects ordinary bees-wax and is prepared from the finer kinds of ozokerite, the inferior sorts being used for the manufacture of paraffin by distillation.

The ozokerite is melted in large vessels capable of holding 300 kilo, over an open fire, and kept at a temperature of 115° to 120° for 4—6 hours in order to expel all water. After the heating sulphuric acid to the extent of 15—20 % is then added in a thin stream. The acid must contain 78 % of SO_3 and the precise amount necessary for a particular specimen of ozokerite determined by previous experiment. The whole is thoroughly stirred whilst the temperature is slowly raised at first to 165° and later to 175°. In this way all the impurities which can be oxidised by H_2SO_4 separate in the form of a black mass known as „asphalt“ and the excess of the acid evaporates. During the process of cooling, which must be slow, a de-acidifying powder is added. This is obtained from the residue in the manufacture of potassium ferrocyanide. After decolorizing with animal charcoal and filtration in a filtering press to remove asphalt, &c., the ceresine is obtained as a yellowish mass. If it be required perfectly white the treatment with H_2SO_4 is repeated, and if on the other hand it be required coloured like bees-wax some artificial colouring matter is added e. g. quinoline yellow.

Ceresine is a white, tasteless, odourless, wax-like mass; M. P. 62° to 80°; S. G. 0.918 to 0.922. It is used in the finishing of cotton and woollen goods, in the manufacture of candles, in perfumery, &c. It is frequently adulterated, particularly when prices are high.

Cerium. Ce. Atomic weight 140.3.

1. Cerium is obtained by the electrolysis of cerium chloride. It is an iron-grey very elastic metal with a specific gravity of 6.73. It ignites spontaneously in the air (surface contact) and burns with intense brilliancy. It is a tetravalent element.

2. COMPOUNDS OF CERIUUM are found in different minerals, but are now mainly prepared from monazite which is an easily decomposed mineral con-

sisting principally of cerium and thorium phosphate. In the process of preparing thorium, cerium is obtained as a by-product in the form of a crude carbonate. According to Germ. Pat. 143106 this carbonate mixture is dissolved in crude HCl and a further amount of the crude substance added together with a certain quantity of potassium permanganate, so that the latter is in excess; a brown precipitate will separate, which contains besides cerium Mg, Cl and CO₂. It is then pressed and extracted. The compounds of cerium are used for the manufacture of incandescent mantles. Cf. INCANDESCENT GAS LIGHTING. According to FORSTER and BRANDEIS (lecture given at the International Congress of Applied Chemistry, Berlin 1903) cerium sulphate is an excellent oxidising agent, which can be used commercially. It is almost equal to KMnO₄ in oxidising power and is readily regenerated by electrolysis. A process for oxidising aromatic hydrocarbons by means of cerium compounds in acid solution, is protected by the Germ. Pat. 158609.

Cetiacol see CETYLGUAIACYL.

Cetylguaiacyl, also called cetiacol and palmiacol. Under these names a remedy for consumption is recommended, which is probably nothing other than pyrocatechin methyl cetyl ether. According to the English Pat. 16349 (1903) it is prepared by digesting a mixture of sodium alcoholate and guaiacol with spermaceti at a temperature of 80°.

It is a solid M. P. 15° at which temperature it decomposes. It is insoluble in H₂O, but soluble in ether-alcohol and chloroform.

It has the same effect as guaiacol, but does not irritate the digestive organs.

Chalk, see LIME.

Chamotte-Stones.

Wehrsteine Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Chamois dressing. For general details see under TANNING. In chamois dressing the skin is made into leather by introducing layers of grease between the fibres of the skin. The oxy fatty acids formed by the oxidation of the fats are so intimately combined with the fibre that the leather can even be washed with soap without decomposition; hence it has received the name of WASH LEATHER. In this method of tanning skins, not only the epidermis is taken off but also the grain, to allow the fat to enter more easily between the fibres. The hide (sheep, goat, &c.) from which the hair has been removed is then freed from lime with acid pickle and after being well wrung out and milled is sprinkled on the grain side with animal fats (blubber, whale oil, &c.) which is then rubbed in by hand. Several skins are then rolled together into a ball and well milled by machinery. After some hours of milling the skins are again oiled, and milled, and so on till no more oil can be absorbed. Finally the skins are piled up in heaps in hot chambers to ferment, oxy acids are formed, the skins swell and the oil is thoroughly assimilated. The superfluous fat is removed mechanically by pressing, or by potash solution. Compare DEGRAS. Chamois leather is used for making gloves, military articles, breeches, and for cleaning glass, polishing silver, &c.

An article resembling chamois leather in all essential qualities is protected by Germ. Pat. 111408. The leather is tanned with dilute formaldehyde in presence of alkalies. This leather has been given the name of CASPINE. Its perfectly white colour, the rapidity with which it can be made, and the high degree of resistance to the effects of even boiling water will probably render caspine a serious rival of chamois leather.

Charcoal. Charcoal is obtained by heating wood in the absence of air. When the main object of the burning is the preparation of charcoal itself

the process is carried out in the simple old-fashioned way, that is by piling the wood in conical heaps, leaving an air passage down the centre, and lighting the heap by means of brushwood. In order to prevent the complete combustion of the wood the heap is covered with earth, turf and fine coal which has been damped. The end of the process is marked by the appearance of the smoke evolved.

By this method the by-products are not recovered, and accordingly the burning is now usually carried out in ovens. See WOOD DISTILLATION.

Charcoal is used as a fuel, for removing the fusel oil from spirits, for clarifying, decolourising and preserving, as a colour and polishing material, and also in the reduction of metals from their ores.

Charcoal burning (DISTILLATION OF WOOD). Charcoal burning has recently become a very important branch of chemical industry. Disregarding the simple charcoal pile the burning is now carried out in ovens from which the products of distillation pass into condensing and cooling chambers. The charcoal ovens are of two types. In one the wood is placed directly in the retort, in the other it is placed in closed vessels. One part of the charcoal furnaces is heated directly as in the charcoal piles, that is, the wood itself is ignited in them; the other part of the charcoal furnaces has a special firing which causes the charring of the contents. In the second type the receptacles for the wood are in the shape either of boxes or cylinders (retorts).

The products of distillation are condensed in condensers and cooling apparatus of which the former act by air cooling whereas the real cooling towers must be fitted with elaborate water cooling. The principle of counter-currents has proved most effective.

The products of distillation are caught in wooden troughs or collecting boxes which are fitted with cocks at different levels so as to facilitate the removal of the different layers.

It is advantageous in charcoal burning to use wood which has been air-dried or still better specially dried. The distillation lasts 12—15 hours. During the first 10 hours the temperature must not rise above 350°, after that it may be gradually increased until 430° is reached.

The products of distillation are collected in receivers fitted with cocks at different heights by means of which the different layers may be separated.

The gaseous products of distillation are ignited and the appearance of the flame shows the state of the process. The condensed products of distillation are allowed to stand several days when the wood vinegar separates from the tar. Charcoal is obtained as a residue in the retorts.

For a long time efforts have been made to find a process by which wood residues may with advantage be submitted to dry distillation. The difficulties in the distillation of wood residues lie in the high percentage of water, the amount of resinous constituents, the large volume, and the low heat-conductivity. The latter prevents the heat penetrating into the interior of the retorts; the water — if the material has not been previously dried — dilutes the liquid products of distillation; the large volume lessens the yield of distillation product from a given size of retort, and the sawdust, &c. because of the resinous constituents present always have a tendency to cake, and form crusts on the hot walls. Numerous patents have been taken out for processes which aim at removing this drawback, but the matter is still in the experimental stage and it cannot as yet be said that the distillation of wood waste has become a rational and profitable process.

A new charcoal-burning process of the firm F. H. MEYER, Hannover, for which a patent has been applied, appears to be of importance. In this process by making use of the latent heat of the vapours of wood vinegar and tar as they escape from the retorts, in an apparatus placed between retort and

condenser, a wood spirit (the so called "light vinegar") absolutely free from tar is obtained from the retorts directly and without a second distillation. This, neutralized with lime and evaporated, gives a grey calcium acetate of great purity. Further by the distillation of pine wood, the whole of the crude turpentine oil is obtained from the retorts separated from the wood vinegar (which is free from tar) and from the pine tar. In this way expenses due to apparatus, steam, cooling water and even wages may be diminished. More recently, processes have been introduced in which superheated steam is used, some of these seem to be of great promise. The products of wood distillation are further worked up, the pyroligneous acid for methyl alcohol, acetic acid and acetone (q. v.), the tar for light and heavy oils.

Charcoal burning:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Equipment for Chemical Works.

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Earthenware apparatus for Chemical Works.

Westdeutsche Steinzeug - Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Chemical apparatus of all kinds.

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Chemical Plant, Enamelled (acid-proof).

C. Harzer & Co., Finsbury Pavement House, London E.C.

Chemical cleaning. By chemical cleaning is understood a chemical process in which the articles to be cleaned are dipped in a fluid which dissolves fat without saponification or emulsion. Compare „Deutsche Färberzeitung“ 1903, No. 34.

The most popular chemical cleaning is carried out by means of benzine (petroleum benzene), so that the whole process is often simply called **BENZINE WASHING**. The articles to be cleaned are carefully sorted according to colour and degree of dirt, which latter is previously removed mechanically so far as is possible, by heating and brushing. Then the goods are thoroughly dried, for none but perfectly dry textiles are cleaned by benzine.

The cleaning itself by benzine is carried out in benzine washing machines in which the goods and the benzine are rocked and rubbed together. Usually the goods are only passed through two benzine washing machines, remaining in each for about 15 minutes. The benzine is then removed from the goods by means of centrifugal machine. The goods are now examined and any remaining dirt or spots, removed by hand with a brush and a solution of benzine soap in benzine. Finally the goods are again rinsed in benzine, beaten and hung up to allow the odour of the remaining benzine to evaporate. Should the goods still show spots a wet washing must be carried out. This is done with soap and water on a washing board by means of a hard brush, care being taken that the water is not over 25°C. After the wet washing the goods are put through weak Na_2CO_3 solution and finally rinsed in running water.

The dirty benzine is purified by distillation. The inflammability of the benzine gives rise to a whole series of dangers, which explains why, for a long time, efforts have been made to find a substitute for it. Benzene, coal-tar benzene, which is also used in chemical cleaning has in this respect very little advantage over petroleum benzine. Carbon tetrachloride is much safer and has been patented for chemical cleaning under the name of **BENZINOFORM**. Cf. **CARBON TETRACHLORIDE**. It is to be regretted that chloride of carbon is considerably more expensive than benzine, so that the latter still remains

the principal material used for chemical cleaning. The ignition of benzene in chemical cleaning establishments is caused, according to the experiments of M. RICHTER, by the spark discharge between the hand of the worker and the benzene. As a preventive for such spontaneous combustion, an addition of $\frac{1}{20}$ to $\frac{1}{50}$ % of magnesium oleate has proved of great service. The protecting action is caused by the increase of the electric conductivity of the benzene by the magnesium compound. The patented name given to the magnesium oleate is ANTIBENZINE PYRINE.

Chemigraphy. Under this term is understood as a rule, those processes of reproduction, in which the plates are produced with the aid of chemical agents. More especially is understood zinc etching, where a zinc plate is etched by means of acids. The strokes of the drawing, being made with a fatty colour, or put on the plate with such, are therefore left untouched by the acid, which enables the copies to be made in a printing press.

Chemol. A cresol soap solution prepared from metacresol. It is a disinfectant and antiseptic sold in original bottles of 100, 250, 500 and 1000 g.

Cherry, Essence of, see FRUIT-ESSENCES.

Chili saltpetre (SODIUM NITRATE NaNO_3). The crude sodium nitrate — known under the name of Chili saltpetre (also soda saltpetre and Peru saltpetre) — occurs in Chili in the form of a salt mixture in layers about 1 metre thick. The amount of sodium nitrate present in this salt mixture (CALICHE) varies from 40 to over 70 %. The Caliche is lixiviated either in open wrought iron pans heated directly with a flame, or still better in vertical cylinders heated by means of steam; the most advantageous appear to be the present dissolving vessels (11 metres long, 1.85 m wide, and 1.85 m high) which are heated by means of steam pipes. In these the crushed caliche is lixiviated with boiling water; the resulting lye is then run off into crystallising vessels where the crude saltpetre separates out. It is dirty and reddish-grey in colour, remains moist even after drying and crystallises in cubical rhombohedra (cubical saltpetre). Crude saltpetre contains between 94—97 % NaNO_3 ; the ordinary Chili saltpetre used as a manure has on an average 95—95.5 % NaNO_3 and 1—2 % NaCl . If the crude saltpetre is to be further purified this is carried out by recrystallisation; it contains then besides NaNO_3 only a small amount of water. Pure NaNO_3 crystallises in large colourless transparent cubical rhombohedra. M.P. 316° — 319° . 100 parts H_2O dissolve at 0° 79.75 pts., at 20° 89.55 pts., at 50° 111.13 pts., at 100° 168.2 pts., at 120° 225.3 pts. NaNO_3 .

In order to obtain NaNO_3 free from perchlorate the Germ. Pat. 165310 recommends lixiviation with small quantities of cold water with constant stirring. The perchlorate remains undissolved.

Chili saltpetre is used in large quantities for the manufacture of H_2SO_4 , HNO_3 and KNO_3 , and many other products. It is further used for purifying caustic soda, as a manure, and for pickling meat.

With regard to the experiments for preparing NaNO_3 from the nitrogen of the air, compare article on NITRIC ACID.

TEST. In Hamburg and also in Chili it is customary only to determine the amount of impurities and consider the rest as NaNO_3 . As impurities are considered water, insoluble products, sodium chloride, sodium sulphate, potassium perchlorate. For determination of H_2O the salt is dried at 120° until weight is constant. The insoluble products are determined by dissolving NaNO_3 in hot water and weighing the residue (after drying at 100°) on a weighed filter paper. The H_2SO_4 determination is carried out with BaCl_2 ; that of Cl titrimetrically with AgNO_3 . K is determined with PtCl_4 . The

perchlorate is determined as follows:— 10 g NaNO_3 (the percentage of Cl must be known) are strongly heated with the same amount of Na_2CO_3 free from chlorine in a large covered porcelain crucible until the fused mass becomes thin and only gives off small bubbles (this is the case after 10 minutes). After dissolving in HNO_3 the Cl from the perchlorate is determined in the ordinary way. — The methods of determining the nitrates must be considered as known.

According to FRESSENIUS (Kongr. f. angew. Chemie, Berlin 1903) the indirect analysis is to be rejected and a direct N determination must be carried out. The following methods are suitable:

- a) Reduction to NH_3 and determination of same in usual manner (ULICH and DEVARDA).
- b) Gas-volumetric method (LUNGE and SCHLÖSING-GRANDEAU).
- c) Driving off N_2O_5 with quartz sand (REICH) and PERSOY:— Heating with $\text{K}_2\text{Cr}_2\text{O}_7$.

China grass, see RAMIE.

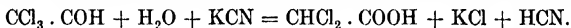
Chirosoter. Solution of waxy or balsam-like bodies in CCl_4 . Recommended as an antiseptic and preventive of infection.

Chloracetic acids.

1. **MONOCHLORACETIC ACID.** $\text{CH}_2\text{Cl} \cdot \text{COOH}$. This is prepared by various methods, but generally by the action of Cl on warm acetic acid in sunlight: iodine is usually added. It is more readily prepared by the action of chlorine or acetyl chloride in presence of phosphorus. It may also be prepared by the action of sulphuryl chloride on acetic acid. According to the Germ. Pat. 157816 the last method is carried out more successfully if acetyl chloride or acetic anhydride is added and the mixture gently warmed. According to this method 60 kg acetic acid are warmed to $55-60^\circ$ with 150 kg sulphuryl-chloride and 0.6 kg acetyl chloride. When the evolution of gas ceases the whole is heated to a temperature above the B. P. of the SO_2Cl_2 and then allowed to cool. Pure monochloroacetic acid then solidifies in a crystalline state.

Crystals, M. P. 62° . B. P. $185-187^\circ$, deliquesce in air and dissolve in H_2O causing a considerable lowering of temperature. In the form of vapour this substance has a caustic action and is used for etching. The main use of monochloroacetic acid is in the preparation of artificial indigo.

2. **DICHLORACETIC ACID.** $\text{CHCl}_2 \cdot \text{COOH}$. This is obtained (in addition to other methods) by warming $\text{K}_4\text{FeC}_6\text{N}_6$ with chloral and water. The HCN in presence of chloral decomposes the water according to the following equation:—



It forms a strongly acid liquid B. P. $189-191^\circ$ crystallizing below 0° .

3. **TRICHLORACETIC ACID.** $\text{CCl}_3 \cdot \text{COOH}$. Obtained by the action of a solution of KMnO_4 upon a conc. solution of chloral. After filtering off the MnO_2 , the solution is saturated with H_3PO_4 and distilled.

Deliquescent crystals, very soluble in water. M. P. 55° . B. P. 195° . Frequently used in medicine as a caustic.

Chloral. TRICHLORALDEHYDE. $\text{CCl}_3 \cdot \text{COH}$. Obtained by the action of Cl on alcohol. Chlorine is led through rectified spirits (96–97 vol. %) for several days, and the HCl formed is collected in suitable vessels. The product of the reaction is first heated with H_2SO_4 under a reflux condenser till no more HCl is evolved, after which the chloral is distilled off. It is purified by distillation.

The process patented by the Germ. Pat. 133021 renders it possible to obtain chloral continuously in closed vessels. The peculiarity of this method is that the alcohol, which is previously treated with chlorine, is acted upon in the

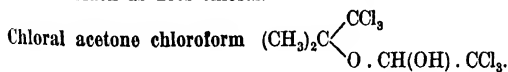
state of vapour by moist chlorine; the result being that all the alcoholate formed by the preliminary treatment is decomposed and the product when treated with H_2SO_4 is free from alcohol and chloral alcoholate and consists only of chloral and chloral hydrate. Thus the decomposition with H_2SO_4 yields a chloral free from ether.

At present chloral is often manufactured electrolytically. A distillation vessel, separated by a diaphragm and filled with a hot solution of KCl , is used. As cathode a copper rod, and as anode a carbon rod, which at the same time serves for stirring the mixture are used. The mixture is kept at about 100° , and during this time alcohol is introduced gradually into the anode chamber. The Cl developed reacts on the alcohol, while the HCl simultaneously formed in the cathode chamber neutralises the KOH there formed. After this process is finished the mixture is distilled, and the chloral is separated by saturating the distillate with salt. 1 HP. per hour yields 50 g of chloral.

It is a colourless, oily fluid with a peculiar, penetrating smell. The vapours affect the eyes causing tears. B. P. 94.4° . With water, acids, alcohol, &c., it forms condensation-products with loss of water.

A solid polymeric chloral is obtained according to the Germ. Pat. 139392 by adding about 7 percent of dry Al_2Cl_6 to chloral, care being taken that the temperature does not exceed 40° . After cooling the product of the reaction is treated with H_2O or dilute mineral acids when the polymeric chloral is left as a white solid. This is then removed, washed first with water, then with alcohol and finally dried at a moderate temperature. The preparation is almost tasteless and has strong narcotic properties. It is used in medical practice. A solid polymeric chloral is also obtained, according to the Amer. Pat. 768744 by allowing pyridine to drop into cooled chloral with continual stirring until the substance begins to solidify. It is then shaken with dilute HCl , after which the residue is separated from the liquid, washed and finally dried.

The Germ. Pat. 170534 protects a method for the preparation of a solid modification of chloral from chloral hydrate or chloral alcoholate. The chloral (or alcoholate) is allowed to stand with conc. H_2SO_4 until a white pasty mass is formed. After pouring off the H_2SO_4 the mass is introduced in small quantities at a time into dilute HCl or H_2SO_4 . When it has become solid, it is drained and the acid removed by washing with a small quantity of cold water and dried *in vacuo* over H_2SO_4 . This substance can be given internally since it is only slightly soluble in water and so does not attack the mucous membrane of the stomach as does chloral.



This substance, according to Germ. Pat. 151188 is obtained by fusing chloral hydrate with acetone chloroform. The product of the reaction which is solid, is dissolved in a suitable hot solvent from which it is then allowed to crystallise.

It forms white crystalline needles which smell and taste like camphor, M. P. 65° . The crystals dissolve readily in alcohol, ether and benzene, but dissolve but little in H_2O . H_2SO_4 decomposes it into chloral and acetone chloroform.

It is said to be an effective narcotic with local anaesthetic qualities, but without the bad after-effects of chloral.

Chloral amide, $CCl_3 \cdot CH(OH)NH \cdot COH$. This product is obtained by the action of chloral on formamide at the ordinary temperature or by treating chloral ammonia with an ester of formic acid.

It forms shining bitter crystals, without smell, which dissolve slowly in H_2O . M. P. 114—115°.

Chloral formamide is used in medicine as a narcotic.

Chloralhydrate. $CCl_3 \cdot CH(OH)_2$. When chloral is mixed with 12.2 % H_2O the liquid solidifies to a crystalline mass which is best purified by recrystallisation from benzene.

The chloralhydrate thus purified forms long sharp needles, which later change into small-grained crystals. The product has an aromatic smell and has a sharp acid taste. It dissolves readily in water and in alcohol and ether. M. P. 57—58°. B. P. 96—98°. It is extensively used as a narcotic.

According to a lecture given by SCHÄER at the International Congress for Applied Chemistry, Berlin 1903, strong solutions of chloral hydrate can be used with great advantage in forensic examinations and in testing medicines and foods, and also in technical analysis.

TEST. For the quantitative determination of chloral hydrate use is made of the fact that when treated with potassium hydroxide it decomposes quantitatively in the cold, into chloroform and potassium formate. 5 g of chloral hydrate are dissolved in 50 ccm of N potassium hydroxide; to this phenolphthalein is added and the excess of alkali titrated at once with N. hydrochloric acid. The potassium hydroxide required for decomposition is then multiplied by 0.16538, to obtain the amount of chloral hydrate in the 5 g of substance taken. If the chloral hydrate contains any uncombined HCl 10 g is placed in a 100 cc flask, 0.5 g of calcium carbonate and 50 ccm of water are added, and the whole well shaken for some minutes. The flask is then filled up to the mark, well mixed and filtered. 50 ccm of the filtrate are then poured into 50 ccm of normal potassium hydroxide and the rest of the test carried out as described above.

Chloranil, see QUINONES.

Chlorbenzoic acids. $C_6H_4Cl \cdot CO_2H$. The o-chlorbenzoic acid has now become the most important of the three isomers, since the synthesis of indigo according to the Germ. Pat. 125456, 142506 and 142507 (see "INDIGO COLOURS") is only successful if this substance can be cheaply prepared.

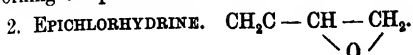
A practicable method of preparing o-chlorbenzoic acid has apparently been found by DIMROTH (Ber. d. Deutsch. chem. Ges. 35.2870). He obtains an anhydro-o-oxymyrric-benzoic acid by heating mercuric benzoate. The former substance is transformed into an o-halogenbenzoic acid when treated with a halogen.

According to the Germ. Pat. 146174 a better yield of o-chlorbenzoic acid is obtained by chlorinating the benzoic acid in dilute solution with alkali and chlorine in molecular proportions, or with the corresponding amount of hypochlorite at a temperature not exceeding 50°. Under these conditions it is possible to conduct the chlorination of benzoic acid in such a manner that of the three possible chlorbenzoic acids the o-compounds are obtained in quantities which make the process applicable on a commercial scale.

Chlorhydrine. This name is given to the chlorine esters of glycerine. The most important of these substances, from a technical point of view, are dichlorhydrine and epichlorhydrine.

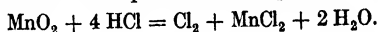
1. **DICHLORHYDRINE** $CH_2Cl \cdot CH(OH) \cdot CH_2Cl$. This substance is formed by heating anhydrous glycerine with chloride of sulphur in common salt bath for several hours. $C_3H_5O_3 + 2 S_2Cl_2 = C_3H_4Cl_2O + SO_2 + 3 S + 2 HCl$. It is a colourless almost odourless syrupy substance, soluble in about 10 volumes of H_2O . S. G. at 16° 1.396. B. P. 176—177°. Its use in industry is on the increase, as it is an excellent solvent for resins, nitro-

cellulose, &c. Further it is not readily inflammable at the ordinary working temperature.



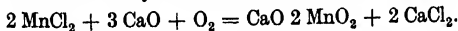
This substance is formed when dichlorhydrine (see above) is heated with about half its weight of powdered NaOH to a temperature not exceeding 130° . It is a mobile liquid having a smell like that of chloroform. S. G. at 15° 1.191, B. P. 117° . It is as good a solvent as dichlorhydrine, and is used as extensively as this substance for the same purposes.

Chlorine. Cl. Atomic weight = 35.45. Chlorine is isolated by different methods 1. from HCl, or $\text{NaCl} + \text{H}_2\text{SO}_4$, and manganese dioxide, or 2. from HCl and air, 3. from chlorides, 4 by using HNO_3 , and 5. by electrolysis. 1. Preparation of chlorine from manganese dioxide. The mixture of $\text{NaCl} + \text{H}_2\text{SO}_4$ formerly used is now usually replaced by starting directly from HCl, which process is carried out in vessels of earthenware, sandstone or granite, sometimes also, though more rarely in vessels of lead, or of iron enamelled or lined with lead. The manganese dioxide is placed in a hanging funnel inside the vessel. The reaction corresponds to the equation:



The work is first carried out in the cold, and when the current of Cl begins to slacken, steam is introduced to raise the temperature. The chlorine is best led away in earthenware pipes.

The acid manganese liquor left as a residue in this process is generally treated by WELDON's lime process. The liquor is neutralised with ground CaCO_3 (and is thus freed from iron). After settling, the liquor containing MnCl_2 and CaCl_2 is put in a cylinder where it is precipitated with milk of lime. After some hours, air is blown automatically into the mixture. WELDON's process is founded on the fact that the manganous hydroxide thus precipitated in presence of lime readily absorbs the oxygen of the atmosphere.

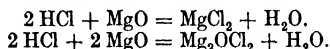


By this process MnO_2 is again obtained from this substance when it is kept at $50-60^\circ$; this MnO_2 is again used for chlorine generation.

2. The manufacture of chlorine from HCl and air, DEACON's process. A mixture of HCl and air is conducted over clay balls which are saturated with some copper salt and heated. Cl is evolved and chloride of copper remains unchanged on the clay balls. This process which apparently consists in the "contact action" of the copper salt is in principle very simple. In practice however it has many disadvantages which till now have prevented it from being generally used. The temperature is usually raised to $370-400^\circ$. The HCl must contain no H_2SO_4 and be as dry as possible. The amount obtained depends not only on the temperature but also on the relative proportions of the HCl and air in the gas mixture. According to Germ. Pat. 145744 the mixture of HCl + air is not heated, but only the air itself, after which the two gases are mixed and conducted over the contact substance. The Germ. Pat. 143828 gives a method for avoiding one disadvantage the DEACON process has, viz., that the impregnated clay balls gradually lose the Cu salt which volatilises as CuCl_2 . The method given in the above patent for the prevention of this is so to arrange the decomposer so that it forms a circular apparatus system in which the Cu salt volatilizes without being able to escape. The Germ. Pat. 150226 makes use of a contact substance of oxides or salts (chlorides), of rare earths such as thorium, cerium, lanthanum, yttrium, &c. Over this contact substance the HCl — air mixture is passed.

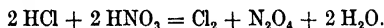
3. Preparation of chlorine from chlorides. For this purpose MgCl_2 , CaCl_2 as well as NH_4Cl are used. The MgCl_2 is usually either dried alone or as a mixture with MgO , then formed into grains or cakes and decomposed in a hot blast furnace or in a current of hot air. $\text{MgCl}_2 + \text{O} = \text{MgO} + \text{Cl}_2$. It is more difficult to decompose CaCl_2 , which is therefore always mixed with materials containing either silicic acid or alumina and decomposed in high towers into which producer gas is conducted.

Chlorine is made from NH_4Cl by dissociating this salt into NH_3 and HCl by heating to a temperature of about 350° . The vapour is conducted over MgO , which at a low temperature combines with the HCl to form the chloride according to the following equations



The unabsorbed NH_3 is drawn off for further use, and from the oxychloride, which must be quite dry, the Cl is obtained by heating in a current of dry air.

4. Preparation of chlorine by the use of HNO_3 . Of the various processes known for this purpose, that of DONALD seems to be of the most practical value. Dry gaseous HCl is conducted through a mixture of HNO_3 and H_2SO_4 , which is cooled to 0°



By passing the gas mixture through dilute HNO_3 , the N_2O_4 is decomposed. The rest of the nitrogen oxide is removed by H_2SO_4 .

5. Chlorine manufacture by electrolysis. This method, now that the difficulties of the electrolytical alkali chloride process have been surmounted, has become of great importance. Compare the article under the heading of CHLORINE-ALKALI PROCESS, ELECTROLYTICAL. For producing chlorine for use in laboratories, the method involving the use of $\text{KMnO}_4 + \text{HCl}$ was recommended by GRAEBE of Geneva, in a lecture given at the 75th meeting of German Physicians and Natural Scientists at Cassel in 1903.

Chlorine at normal temperatures is a greenish-yellow gas with a penetrating choking smell. It is extremely poisonous and destructive. Under a pressure of 6 atm. at normal temperatures it condenses to a dark yellow liquid. The S. G. of gaseous chlorine is 2.45. 1 litre weighs 3.17 g at 0° and 760 mm pressure. — The gas dissolves readily in water (at 20° about double the volume, at 8° about three times the volume; the solution being then of a greenish-yellow colour). The chlorine water on cooling to 0° gives crystals of chlorine hydrate $\text{Cl}_2 + 8 \text{H}_2\text{O}$. Liquid chlorine has according to LANGE the following properties. S. G. 1.469 at 0° , 1.426 at 15° , 1.381 at 30° . Vapour pressure 3.7 at 0° , 5.8 at 15° , 8.7 at 30° . 1 kg at 0° and 760 mm pressure yields 316 litres of gas. Critical temperature 146° . Critical pressure 93.5 atm. Boiling point at 760 mm — 33.6° . Melting point of the solid — 102° .

Liquid chlorine has become of importance as it is now in such general use, even to a certain extent taking the place of bleaching powder for purposes for which this substance was formerly exclusively used. According to Germ. Pat. 50329 pumps are used for compressing this gas, in which those parts which come in contact with the gas are covered with concentrated H_2SO_4 , which also serves as a lubricant. At present it is becoming more and more general simply to cool the Cl in refrigerators so that it liquefies at normal pressures. It is a curious fact that compressed and liquid chlorine in an absolute dry condition is entirely without action on cast iron, wrought iron, steel, Cu, Zn, Pb, brass or phosphor bronze; only as stated every trace of moisture must be absent. Liquid chlorine is thus brought to the market in bronze, steel or lead-lined iron vessels.

For chlorine for bleaching, see BLEACHING.

Chlorine-Developer:

F. Chr. Fikentscher, Ltd. Zwickau Sa., Germany (see front part advt.).

Chlorine-Developing vessels of Earthenware:

Westdeutsche Steinzeug-Charotte- und Dinaswerke G. m. b. H., Fuskirchen, Rheinland (Germany) (see front part advt. p.).

Chlorine-alkali Process, electrolytical. This is unquestionably the most important of those electrolytical processes which are based on the decomposition of aqueous electrolytes. By the name chlorine-alkali process is understood the method in which chlorine and the alkalis are simultaneously prepared. The simple decomposition according to the equation $\text{NaCl} = \text{Na} + \text{Cl}$ in which Cl is liberated at the anode, while metallic Na separates at the cathode, is complicated to quite a considerable extent by secondary reactions. In the first instance the Na combines with the H_2O of the electrolyte to form NaOH, and as the caustic alkalis have at least four times the market value of the alkali chlorides the preparation of NaOH from NaCl (or of KOH from KCl) is of considerable value. Unfortunately, the above is not the only change that occurs but the sum of the reactions taking place during electrolysis. On the contrary a number of other processes take place simultaneously, which disadvantageously influence the success of the whole procedure, and in fact under some circumstances render it financially worthless.

The caustic alkalis (potassium and sodium hydroxide) which are formed during electrolysis are themselves good conductors of electricity. They are therefore again decomposed and thus oxygen is set free at the anode as well as the primary product, chlorine, while hydrogen appears at the cathode. Thus the difficulty of a continuous process in which electrical energy is used without being of any practical value has to be faced. These undesirable secondary reactions causing the decomposition of the caustic alkali become more marked as the amount of alkali increases, the decomposition being proportional to the strength of the solution.

Other reactions also take place, which it is true are useful in some cases and are then carried out; they must be considered injurious and disadvantageous, however, in the electro-chemical manufacture of caustic alkalis.

For example one of the reactions in question is the formation of hypochlorite through the action of chlorine on the caustic alkali at the anode. This secondary reaction corresponds to the equation: $2\text{NaOH} + 2\text{Cl} = \text{NaOCl} + \text{NaCl} + \text{H}_2\text{O}$. Further a part, or indeed the whole of the alkaline hypochlorite can be oxidised by the oxygen developed at the anode, with the formation of chlorate in accordance with the equation: $\text{NaOCl} + \text{O}_2 = \text{NaClO}_3$.

These above mentioned secondary reactions are by no means all that occur. For example the hypochlorite is further decomposed by the electrolysis forming caustic alkali, hydrogen, hypochlorous acid and oxygen, while the chlorates are electrolysed into caustic alkali, hydrogen, chloric acid and oxygen. Finally those portions of the hypochlorites and chlorates which reach the cathode through diffusion, or which reach it by means of the electrolytes, are reduced by the hydrogen there liberated and thus form alkaline chlorides, that is, the same combination is again formed as that which existed at the beginning of the electrolytical process.

For the manufacture of caustic alkalis it is absolutely necessary to prevent the harmful retarding secondary reactions above described, or at least to reduce them as far as possible, and for this purpose there have been proposed several remedies which will be explained at length in the following pages.

a) **DIAPHRAGM PROCESS.** The decomposition cell can be separated into two compartments by a membrane through which the current can pass, each of which divisions will then contain an electrode. These are called the decom-

position cells of the electrode in question, the anode cell and the cathode cell. The membrane forming the partition is termed the diaphragm.

The „alkali process with diaphragm“, the so called diaphragm process, owes its development principally to the „Electron“ Chemical Factory, GRIESHEIM. Many difficulties had to be overcome and there are many more which will never be overcome, for they form an integral part of the process itself. The material of the diaphragm is a subject on which no settled conclusion has yet been reached. The diaphragms must be proof against the effects of chlorine and alkali, must have little or no electric resistance and finally must be able to prevent as far as possible the diffusion of the alkali into the anode cell. We can mention as most practicable a diaphragm of porous Portland cement, one of asbestos prepared with sand or infusorial earth, and finally a diaphragm in the form of a moulded sheet of soap.

The diaphragm of burnt porous clay, as used in the form of clay cells for galvanic batteries, has proved less practical for this purpose. To prevent the further decomposition of the alkali, alluded to above, the concentration must not be greatly increased when making use of the diaphragm process, as the decomposition increases with the contents of caustic alkali. Therefore the caustic lye must be drawn off as soon as it contains 10—12 % of alkali. When it is further calculated that the diaphragm process can only work with a weak current, to lessen the destruction of the diaphragm and the carbon anode, which is effected by the oxygen there developed, and further, that the diaphragm can never completely prevent diffusion, we have mentioned the principal disadvantages of the diaphragm method of the electro-chemical alkali process. Despite these disadvantages the process in question has gradually been made more and more practical and it yields quite respectable financial results. Another disadvantage this process has, which the mercury process detailed below does not possess, is that the lye which has to be reduced after the electrolysis, contains, besides the caustic alkalies formed, also a great deal of the original chloride.

That despite this the diaphragm can hold its own against the mercury process is due to the circumstance, that the chloride can be separated much more rapidly and readily by the reduction of the lye than would be expected judging from its solubility. This is due to the strong „salting out“ action of the caustic alkali in concentrated aqueous solution.

The circumstance that in the diaphragm process diffusion between the anode and cathode cells is never quite prevented, explains why at most 80 % of the theoretical yield is obtained. This fault the Germ. Pat. 144392 endeavours to make good by introducing an intermediate cell between the anode and cathode. Each of the three cells is fed separately and the middle cell is supplied with a metallic peroxide. By heating the electrolyte the level of the columns of liquid is maintained at a different height in the middle cell and the cathode cell on the one hand, and in middle cell and the anode cell on the other, so that by means of the osmotic pressure the cathode fluid and the anode fluid penetrate into the middle cell in proportions necessary for the formation of the alkali chloride, thus producing by their combination a new supply of the electrolyte in the middle cell. It is a good plan to let the cathode fluid flow by hydraulic pressure or counter pressure through several separate cells from such varied heights that the difference between inner and outer pressure increases with the increasing amount of caustic soda in the liquid.

As to the question of the electrodes the cathode can be formed of any metal. Generally the decomposition vessel itself serves as cathode, being made of cast iron or wrought iron. On the other hand there are few materials which are good conductors and, at the same time, suitable for electrodes, or which can resist the action of substances such as chlorine and oxygen, and

the hypochlorous and chloric acids which are formed at the anode. In practice as a matter of fact, the anodes are almost always either carbon rods or carbon prisms. The rods or prisms are either made of RETORT GRAPHITE (q. v.), or formed of artificial carbon by compressing a mixture of anthracite and tar under several atmospheres and then heating the pieces for a considerable time to about 1000°C cf. ELECTRIC CARBONS.

The French. Pat. 390963 protects a process in which the electrolysis of alkaline chloride solutions is carried out by the use of a diaphragm and anodes of copper. It is said that in this case hypochlorites and chlorates are not formed and further, that in addition to the caustic alkalies CuCl_2 is obtained by the action of Cl on the copper anode in the form of powder which is later converted into CuSO_4 by means of concentrated H_2SO_4 . This process is probably of no great practical value.

b) MERCURY PROCESS. In this method the alkali metal set free at the cathode is, as soon as liberated, alloyed with mercury. In this case the Na or the K is prevented from attacking the water of the electrolyte, and instead of this dissolves in the mercury, thus forming sodium or potassium amalgam. It is true the caustic alkali desired is so far not prepared, but this can be done without difficulty by bringing the amalgam into contact with water. The mercury then separates while the alkali metal combines with the water to form caustic alkali.

The process in question as may be easily understood can be carried out in many ways, and indeed very varied methods of procedure are adopted.

One kind of difficulty with which the diaphragm process has to contend is avoided in the mercury process from the beginning viz. the troubles which arise from the presence of the solid diaphragm. These are difficulties that are absent when Hg, which may be regarded in a sense as a liquid diaphragm is used. On the other hand, however, the mercury process had, at the beginning, many other shortcomings. For a long time there was no known way of preventing the amalgam which is of lower density from floating on the mercury. The mercury lying under the amalgam was not able to come in contact with the newly-formed alkali metal while the amalgam because of its increasing content of alkali metal underwent further decomposition. This objection has now been done away with, the best preventive apparently being the method given by CASTNER. CASTNER's apparatus consists of a rocking trough which is shallow and divided by two partitions. The partitions do not reach quite to the bottom of the trough, the open part being shut off as it were by the Hg which is poured into the vessel. In the one part of the trough the NaCl or KCl solution which is introduced, is electrolytically decomposed, the Cl is led off, and the Na or K dissolves in the Hg. As, however, the Hg in the trough is rocked to and fro, the amalgam which forms must pass into the other part of the trough where it becomes attacked by the pure water with formation of a caustic lye and evolution of H . Further details of the matter can not be given here. The alkaline lyes produced by the mercury method is free from chloride, an advantage over the diaphragm method on the one hand, while on the other hand they are not so concentrated and therefore require a much longer process of concentration than the lyes obtained by the other method.

The Germ. Pat. 142713 protects an apparatus for the mercury method, where the iron bottom plate is insulated as regards the greater part of its surface, from the Hg lying over it, with which it is only connected by a conductor of small cross-section. In the apparatus described in the Germ. Pat. 145749 the Hg drips over upright or slanting iron plates closely fitted with narrow grooves.

The object of this is to counteract the great increase of surface tension of the descending amalgam. A combination of the diaphragm and mercury process is aimed at in the Danish. Pat. 8529 (1905).

c) BELL METHOD. The so-called bell method is in principle a compromise between the diaphragm and the mercury methods. In to a shallow trough a bell dips, in which hangs the carbon disc-shaped anode which is nearly as great in diameter as the vessel. The iron cathodes dip into the electrolyte out-side the bell. The electrolyte is conducted by a continuous current into the bell and flows over the edges of the trough charged with caustic alkali. According to the work of ADOLPH (*Zeitschrift für Electrochemie* 1901, 581) the bell method is based on the fact that between the solution in the anode bell and that out-side in the cathode space a liquid diaphragm-like separating layer is formed and kept automatically intact by the different densities of the fluids.

The effect is said to be more complete than in the diaphragm process. The bell method permits of much more concentrated alkaline lyes being formed (100—150 g caustic alkali in 1 litre) without affecting the initial current, provided, — this is remarkable — that the anode is of carbon and not of platinum.

The bell method is also known under the name of the AUSSIG method, because it originated in the chemical factory of AUSSIG. The process is protected by the Germ. Pat. 141187. Its application has been already extended, its success being due to its great and indisputable advantages.

The Germ. Pat. 107917 and 142245 deal with a bell apparatus for chlorine-alkali electrolysis in which the horizontally placed anode is surrounded by the bell while the cathode is kept outside. The cathode lye flows off through several symmetrically placed openings.

The most valuable products of the electrolytic chlorine-alkali process are NaOH and KOH. Of course it is possible to obtain the carbonates (K_2CO_3 and Na_2CO_3) instead of the hydroxides, by conducting CO_2 into the caustic alkali lye while it is being formed or after it is formed. But such procedure would be neither advantageous nor economical, because the great amount of energy expended on the production of the caustic alkalies would to a large extent be wasted.

The fact that the Cl, which is valuable industrially separates at the anode and that if special preventive measures are not taken hypochlorites are formed has led to the introduction of processes which aim at the direct electrolytical production of bleaching liquors containing hypochlorites. In the HERMITE process, for example, a solution of magnesium chloride to which 5 % rock salt and 0.5 % sea salt is added, is subjected to electrolysis (5 volts) to form a bleaching liquor which contains hypochlorous, chlorous and chloric acids.

In the production of hypochlorites a principal source of loss of current is the partial reduction of the hypochlorites at the cathode. The Germ. Pat. 141372 carries out the electrolysis in the presence of compounds of the alkaline earths and a small quantity of solutions of resins in order to reduce the loss of current as far as possible, and to obtain highly concentrated hypochlorite solutions. If, for example, 14 litres of a 10 % NaCl solution with 40 g $CaCl_2$, 30 g $Ca(OH)_2$ and 50 ccm of resin solution made by dissolving colophony in soda solution be electrolysed with 125 amp, after 1 hour 9 g of active Cl per 1 litre will be present; after 3 hours there will be 23 g, after 6 hours 33.5 g of Cl per litre, in the form of hypochlorite.

If the principal object be the formation of chlorates and perchlorates by the secondary electrolytic reactions, there are various conditions which have to be observed. The methods which have been published differ very greatly in respect of the strength of the electrolyte, temperature, the current density &c. But all agree in one respect that warm solutions of the alkaline chlorides must be used. All the methods agree that the electrolyte must be alkaline and not neutral. If KCl solution is decomposed for the purpose of obtaining $KClO_3$, potassium hydroxide must be added and continually supplied

so as to keep the electrolyte alkaline. Other methods recommend the addition of K_2CO_3 instead of potassium hydroxide.

According to Germ. Pat. 136678 small quantities of chromic acid or bichromate are added for the electrolytic production of chlorates and perchlorates. HCl in solution is added continuously in small amounts during the process of electrolysis in order to keep the chromic acid in the state of bichromate and not as chromate.

After the process is finished the anode liquid is evaporated, and the mixture of KCl and $KClO_3$ separated by recrystallisation. Platinum seems to be the only suitable anode for the production of chlorates. The cathode is usually of iron.

It should be noticed that some of the apparatus used for the electrochemical manufacture of chlorates are fitted with a diaphragm, others again are used without any such appliance. According to the Germ. Pat. 141372, described above, chlorates are obtained if one alteration in the method of procedure is made, that of electrolysis in hot instead of in cold solutions. According to the Germ. Pat. 143347 a greater current power is exerted on the electrolyte at the anode than at the cathode for the purpose of obtaining chlorates and perchlorates. Part of the current is in this case diverted from the anode to an assistant cathode placed in a cell divided from the actual decomposition vessel by a porous partition; when this arrangement is used there is always a certain amount of hypochlorous acid in the solution, which is easily acted upon and rapidly converted into chloric acid. This combines with the alkaline hypochlorite to form a chlorate and hypochlorous acid is again set free.

The Germ. Pat. 144109 deals with the continuous formation of chlorates by allowing the solution to be electrolysed to flow without intermission through cells which have no diaphragm, keeping it at such a temperature (40–95°) and so regulating the rapidity of flow, that on the one hand any hypochlorite which is formed must be again decomposed, while on the other hand the liquor which flows out contains little more than 3 % of chlorate.

According to the Germ. Pat. 153859 fluorine compounds are added to the electrolyte for the manufacture of salts of the halogen acids. With addition of these compounds a much larger yield of chlorate is obtained by the electrolysis of warm KCl or NaCl solution, without the use of a diaphragm. The fluorine should be in the form of HF or in the form of such compounds as develop free HF in electrolysis.

The Germ. Pat. 159747 advises the addition of a small quantity of chloride of lime solution to the electrolytes for obtaining chlorates. The process should be carried out with a current strength of 1000 amp. to 1 sq. m. of cathode surface at a temperature of 80–100°.

In this way it is said that an excess of lime will be deposited at the cathode, which will lessen the reduction, while at the same time hypochlorous acids will immediately form at the anode, which will hasten the formation of chlorate by their oxidising properties.

According to the French. Pat. 339251 small quantities of resin, salts of the alkaline earths and dilute HCl are added to the electrolyte in the preparation of chlorates and perchlorates.

According to the Amer. Pat. 788631 chlorates and perchlorates are simultaneously obtained by electrolysis, if chloride of lead is added to the electrolyte. In this case hydroxide of lead is precipitated which is transformed into peroxide of lead.

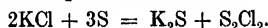
Until recently the process of obtaining caustic alkalies by electrolysis was only considered feasible with aqueous solutions as electrolyte and the possibility of making use of a fused electrolyte was not seriously entertained. Now, however, this idea has gained ground, and as reported on the best authority the ACKER¹ process for the manufacture of NaOH is thoroughly

practical and a financial success. The process in itself is not quite new, as shown by the number of the patent (114739) but it has taken a long time to find out how the many difficulties connected with it may be overcome. In this so-called ACKER Process fused NaCl is electrolysed; graphite cylinders serve as the anodes, and fused lead as the cathodes. The lead flows rapidly through the decomposition furnace and takes up 4 % of Na. The lead which is alloyed with Na is subjected to a steam jet at a pressure of 3 atm. which keeps the alloy in motion and then converts the Na into NaOH. The temperature is kept just above the melting point of the NaCl without external heating by the heat of the current alone. The hydrogen burns at the mouth of the furnace, from which also the molten NaOH flows continuously into the receiver in which it solidifies. The Cl is drawn off through a ventilator; the yield exceeds 90 %. Each furnace is worked with 8000 amp. The only disadvantage reported is that 6.75 v are necessary whereas only 4.5 volts are needed for the wet process.

Chlorine compounds. The chlorides are described under the various metallic and radical compounds e.g. chloride of calcium under calcium chloride, ethyl chloride under ethyl compounds. The same holds good in the case of chlorates and perchlorates. There are special articles on CARBON TETRACHLORIDE, CHLOROFORM, BLEACHING POWDER, HYPOCHLORITES. Compare further the article on Bleaching. Here follow only details on the subject of sulphur chloride, sulphur dichloride, sulphuryl chloride, thionyl chloride, chloric acid and chlorsulphonic acid.

1. **CHLORIDE OF SULPHUR.** Monochloride of sulphur S_2Cl_2 . This compound is obtained by passing pure dry chlorine gas through melted sulphur which is heated to 125—130°. The S_2Cl_2 formed is condensed in a well-cooled receiver. It still contains uncombined sulphur in solution and must be freed from this by repeated distillation.

According to Germ. Pat. 49628 (now expiring) S_2Cl_2 is also formed by the action of S on fused potassium chloride.



S_2Cl_2 is a thick brownish liquid with a choking smell which fumes in air. S. G. at 0° 1.706, B. P. 138°.

Sulphur monochloride is a good solvent for sulphur. It transforms linseed oil into varnish and rape-seed oil into a caoutchouc like material. It is mainly used for vulcanising caoutchouc.

According to Roy D. HALL S_2Cl_2 is a convenient agent in the preparation of metallic chlorides. If for instance the oxides of W, Mo, V, Fe, Cr or Al are heated in S_2Cl_2 to 200°, they are transformed into the respective chlorides.

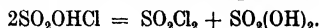
2. **SULPHUR DICHLORIDE.** SCl_2 is obtained by saturating S_2Cl_2 in the cold with Cl and then removing the excess of Cl by passing a current of dry CO_2 through the liquid. It is a reddish brown oil S. G. 1.62 which decomposes at 64° into S_2Cl_2 + Cl_2 .

3. **SULPHURYL CHLORIDE** SO_2Cl_2 . Formerly this substance was exclusively made by passing SO_2 and Cl into glacial acetic acid or the above-named gases were allowed to act upon camphor either alternately or together.

According to Germ. Pat. 138531 both the gases are allowed to react in the liquid state in presence of substances which bring about combination. The reaction occurs almost immediately. Glacial acetic acid, camphor, formic acid &c. are used as contact substances.

In another process, protected by the Germ. Pat. 129862, the sulphuryl chloride is made by boiling chlor-sulphonic acid with mercury, mercuric

sulphate or some other suitable substance for 2—3 hours in a vessel fitted with a reflux-condenser. The reaction corresponds to the equation



If the temperature of the reflux condenser be kept at about 70°C , almost the whole of the SO_2Cl_2 will pass over in the time mentioned.

It is a colourless liquid which gives off pungent fumes when exposed to the air. S. G. 1.66 at 20° . It has a strong chlorinating action which leads to its being much used for making acetyl chloride, benzyl chloride &c. See ACETYL CHLORIDE and BENZYL CHLORIDE. A special method of chlorinating is protected by the Germ. Pat. 146796. The Germ. Pat. 160102 and 162394 protect methods for recovering the unused chlorinating agent, SO_2Cl_2 .

4. THIONYL CHLORIDE. SOCl_2 was formerly prepared by the action of phosphorus pentachloride on sulphur dioxide, or on a sulphite. $\text{SO}_2 + \text{PCl}_5 = \text{SOCl}_2 + \text{POCl}_3$. Recently sulphur trioxide and SCl_2 have been employed for this purpose. This method is protected by the Germ. Pat. 136870. If the reaction is carried out below the boiling point (-10°) of SO_2 , or under pressure, an almost theoretical yield is obtained.

The Germ. Pat. 139455 makes use of sulphur monochloride instead of SCl_2 and sulphur trioxide. The reaction takes place at a temperature of $75-80^\circ$, $\text{S}_2\text{Cl}_2 + \text{SO}_3 = \text{SOCl}_2 + \text{SO}_2 + \text{S}$. The S formed by the reaction is at the same time immediately transformed into S_2Cl_2 by leading Cl into the mixture.

It is a colourless liquid which on exposure to the air gives off pungent fumes. B. P. 78° , S. G. at 0° is 1.676. Thionyl chloride is said to be employed in the manufacture of dyes and intermediate products. It is now also used for the preparation of acetic anhydride.

5. CHLORIC ACID HClO_3 . Chloric acid is obtained commercially by decomposing barium chlorate with dilute H_2SO_4 and evaporating the clear solution *in vacuo*.

It is a pale yellowish fluid S. G. 1.120.

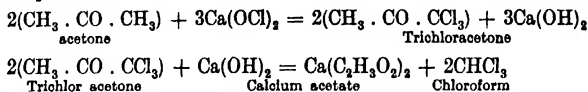
6. CHLORSULPHONIC ACID $\text{SO}_2\text{Cl}(\text{OH})$. This acid is formed by the direct combination of sulphur trioxide SO_3 with dry HCl. It is easily obtained by leading HCl into pyro-sulphuric acid and then distilling. According to Germ. Pat. 160102 it is obtained by leading the gases produced by chlorinating with sulphuryl chloride into fuming H_2SO_4 . These gases always contain, besides SO_2 and HCl, considerable quantities of sulphuryl chloride, and on being led into the acid, chloresulphonic acid is formed from the HCl, as well as from the sulphuryl chloride. The acid can be again transformed into sulphuryl chloride.

It is a colourless fluid S. G. at 0° of 1.785. B. P. is 158° ; it is a mono basic acid.

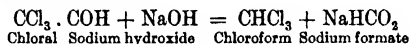
Chloroform CHCl_3 , trichlormethane. The manufacture of this substance is carried out in various ways. One is to warm alcohol with a solution of bleaching powder to about 60° care being taken to keep to certain proportions. In this way CO_2 is first formed by oxidation of the alcohol which sets free hypochlorous acid from the bleaching powder; further aldehyde and chloral are formed and these are decomposed by caustic lime into CHCl_3 . The chloroform formed is then distilled off and separated from the H_2O which has distilled with it. After this it is treated first with soda then with concentrated H_2SO_4 , finally washed with H_2O , dried over CaCl_2 and distilled.

More general than this is the method of obtaining chloroform from the crude acetone of the pyroligneous acid manufacture, which is carried out as follows. The acetone, which is diluted with H_2O is gradually mixed with a solution of bleaching powder. The formation of chloroform readily takes

place and it is only near the end of the reaction that any heat is required. Certain proportions must be used when mixing. The reaction corresponds to the equations



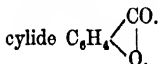
Very pure chloroform is produced by the distillation of chloral or chloral hydrate with sodium hydroxide



From this so-called chloral-chloroform the well known preparation denominated "Chloroform Pictet" is produced. It is prepared from the chloroform by freezing this compound to -75° .

Among the other methods for obtaining chloroform the electrolytic one is of interest. By this patented process, an alcoholic sodium chloride solution is decomposed by an electric current.

According to a new process protected by the Germ. Pat. 129237 CHCl_3 is obtained by warming alcohol, which has previously been chlorinated, with bleaching powder and alkalies. The chlorination product used for chlorinating (e. g. chloral, chloral alcoholate &c.) must have a density of 35°Bé . A vessel is used which can be heated and which is provided with a transport pipe. The vessel is partitioned into several compartments which communicate at the bottom with each other and are connected by a pipe over the top. The compartments are fed by feed pipes, connected with a vessel containing the necessary reagents. The partitions serve the purpose of allowing the liquid substances and the gaseous product of reaction to come into intimate contact while passing, (principle of counter-current). A very pure form of CHCl_3 is the „ANSCHÜTZ“ chloroform, which is prepared from salicylide chloroform. The internal anhydride of salicylic acid, the so called sali-



(see SALICYLIC ACID) has the property of forming a crystalline compound with CHCl_3 . If salicylide is dissolved in crude chloroform salicylide chloroform very rapidly crystallises out $(\text{C}_6\text{H}_4\text{O} \cdot \text{CO})_4 + 2\text{CHCl}_3$ and the impurities are left in the mother liquor. If the salicylide-chloroform is heated on the water bath, the salicylide remains while the chloroform volatilizes.

The chloroform used for medical purposes must contain 1 % absolute alcohol or it undergoes decomposition.

CHCl_3 is a colourless, ethereal, sweet smelling and tasting mobile fluid S. G. 1.526 at 15° , B. P. 61.2° and M. P. -70° . It is a valuable medical anaesthetic and in chemistry it is used as a solvent for many organic substances, and in the manufacture of dyes.

Chloroform from chloral acetone, see CHLORAL ACETONE CHLOROFORM.

Chlorophyll occurs in the form of granules in leaves of green plants. It is soluble in chloroform, alcohol, ether, and oils. The solution has a blood-red fluorescence, but readily decomposes.

Chlorophyll:

Oscar Wender & Co., Dresden, Germany.

Chocolate. A mixture of cocoa and sugar with, in most cases, an addition of flavouring, usually vanilla. For details of the preparation of the cocoa see the article on COCOA. The machines for mixing the cocoa are similar to crushing mills q. v. They have a circular grinding plate on which roll cylindrical, pyramidal or ellipsoidal stones. The working surfaces of the rollers have not only to crush but also to knead the ingredients well together. In other machines (the so called *melangeurs*) the plate itself, which forms the bottom, rotates. The plate, whether it rotates or not, is in both machines heated from underneath by a flexible steam pipe. This keeps the cocoa soft and moist, thus assisting the work of mixing. The chocolate paste when ready goes through several machines for removing the air bubbles thus rendering it denser and harder. This machine is often combined with a cutting apparatus. The soft pieces of chocolate thus separated are pressed into shallow metal moulds which are then placed on oscillating or vibrating tables. By keeping the moist chocolate in continual movement it fills all the interstices of the moulds with great nicety. After this the chocolates, still in the moulds, are placed in a cool cellar. When they are quite firm the chocolates can be easily removed from the moulds.

Pure chocolate has usually 48—62 per cent of sugar (average 54 per cent), 18—27 per cent of oil (average 22 per cent) and 1.08—1.75 per cent of ash (average 1.39 per cent).

Machines for manufacturing Chocolate:

J. M. Lehmann, Dresden-A. 28, Germany (see front part advt.).

Worner Pfeleiderer & Perkins Ltd., Peterborough.

Christoffle, see NICKEL ALLOYS.

Chromium. Cr. Atomic weight = 52.14. The principal material for the manufacture of chromium and its compounds is chrome iron ore FeCr_2O_4 . The metal chromium itself, until a short time ago could scarcely be obtained quite pure and formed one of the rare chemical substances. It was obtained by one method from chromium chloride at a red heat by passing sodium vapour fumes over it in an atmosphere of hydrogen. It was also obtained in electric furnaces by the reduction of chromium chloride by means of carbon. By the latter and most simple process a chromium containing carbon was obtained which, because of its carbon contents seemed little adapted for its most important use, viz. the manufacture of chrome steel. Of late the electrolytical process of obtaining chromium starts from potassium chromium chloride. These difficulties are now however all overcome and the chromium is obtained, absolutely free from carbon, by the process known as aluminothermy, that is by burning a powdered mixture of oxide of chromium and metallic aluminium. For details of this process given by GOLDSCHMIDT and known under his name see the article on THERMITE.

According to Germ. Pat. 147326 the metals of the iron group, for instance, chromium, are manufactured in electric furnaces. The ore which is mixed with as much carbon as is necessary for the reduction of the metal into a spongy form is reduced in a blast furnace which is connected with a refining furnace, and the metallic sponge is fused electrically by a strong current. The gases escaping from the furnace are used for heating the refining furnace while the metal is collecting there, and are then returned to the shaft furnace to raise it to the required temperature.

According to the Amer. Pat. 759424 powdered animal carbon is mixed with zinc chromite and a suitable binding material and pressed under great pressure into solid cakes which are then heated. The zinc volatilizes while the chromous acids are reduced to metallic chromium. The process does not appear very promising from an economical or financial point of view.

According to a report by Dr. CARL GOLDSCHMIDT, Lucerne, Chem.-Ztg. 1905, 56 it is possible to separate Cr catalytically from its salts in presence of tin or tin compounds, the best results being obtained with crystallized chromium nitrate. If a chromium nitrate solution is allowed to stand in a tin vessel in the cold (of winter), in one day amorphous as well as crystalline Cr will separate. The chromium hydroxide can be removed by excess of alkali.

Chromium forms a light grey, glittering crystalline powder, or when fused a steel-blue substance, capable of taking a polish. S. G. 6.8. It melts in the electric furnace at above 2000° . It is not acted upon by HNO_3 while in warm dilute HCl or H_2SO_4 it readily dissolves.

An addition of chromium renders metals and alloys more resistant to many chemical agents and also makes them more difficult to fuse. For these reasons chromium steel is widely used. Cf. IRON ALLOYS.

Chromium Colours.

1. **BIARIUM YELLOW, ULTRAMARINE YELLOW or CHROME YELLOW**, BaCrO_4 . Obtained by precipitating the solution of BaCl_2 or of another Ba salt with K_2CrO_4 . A very stable colour used in numerous tints and shades.

2. **CHROME BLUE**. A chromium silicon phosphate obtained by fusing a mixture of potassium chromate, fluor spar and silica in certain proportions.

3. **CHROME YELLOW**, lemon yellow, royal yellow, Leipzig yellow, Cologne yellow, lead chromate, Paris yellow, new yellow PbCrO_4 . Obtained by the action of K_2CrO_4 on a solution of a lead salt; acetate of lead yields the finest tints. It is a colour which is supplied in different shades and tones.

4. **CHROME RED** (Chrome cinnabar) basic chromate of lead $\text{PbCrO}_4 + \text{Pb}(\text{OH})_2$. Made directly from basic acetate of lead by precipitation with Na_2CrO_4 or indirectly by treating chrome yellow with a caustic alkali or an alkaline carbonate.

5. **CHROME ORANGE**. A mixture of chrome yellow and chrome red.

6. **CHROME GREEN** (green cinnabar, oil green, leaf green) Cr_2O_3 . The best colour is obtained by heating to a red heat salts of chromic acid. Those made by precipitating chrome solutions with Na_2CO_3 and heating the $\text{Cr}_2(\text{OH})_6$ thus produced to a red heat are less fine.

7. **EMERALD GREEN** is $\text{Cr}_2(\text{OH})_6$ obtained by precipitating a chromium salt solution with zinc hydroxide. When carefully washed and dried it serves as a paint.

8. **ZINC YELLOW** (zinc chromate). This colour is prepared by precipitation of a solution of zinc salts with an alkali chromate. It is mainly composed of a basic chromate. It is a much-prized paint on account of its extreme fastness to light.

9. **ZINC GREEN**. A mixture of zinc yellow with Paris blue. For the latter see under IRON COLOURS.

RINMANN'S green also passes under the name of zinc green. Compare COBALT COLOURS.

There is still a number of other chrome colours consisting partly of chromium hydroxide and partly of chromium borate, as for instance GUGNET'S green which contains principally chromium phosphate. A chrome green varnish is made of a mixture of chromium oxide and aluminium oxide. A mixture of Paris blue and chrome yellow can be used as a chrome green or a colour similar to Paris blue can be mixed with the chrome yellow. Many of the coal-tar colours are known by names which might lead to the belief that they were chromium colours. The iron chrome colours are treated of under IRON COLOURS.

Chromium Compounds. The chromates are to be found under the compounds of the respective metals.

See also CHROMIUM MORDANTS and CHROMIUM COLOURS.

According to the Germ. Pat. 143320 and 146491 in order to prepare chromium compounds solutions of salts of the alkalies are electrolysed using an anode of chromium or ferro-chrome in an apparatus with a diaphragm. Instead of this, the solution of a chromium salt can be electrolysed, the process being worked with an insoluble anode. As anode solution in this case, a mixture of chromium sulphate and potassium sulphate is used which is kept alkaline by the addition of lime.

Chrome iron ore can be used for the preparation of Cr compounds according to the Amer. Pat. 743668 by heating the ore together with excess of H_2SO_4 and an oxidising agent, conducting an electric current through the solution and separating the precipitated insoluble iron compounds from the chromium sulphate by filtration.

See also POTASSIUM AND SODIUM CHROMATES.

1. CHROMIUM ACETATE. A solution of the normal salts is obtained by mixing solutions of chrome alum and acetate of lead.

2. CHROME ALUM see ALUMS.

3a. CHROMIUM CHLORIDE Cr_2Cl_6 . For the wet process of manufacture, see under CHROME MORDANTS. The dry method for obtaining this compound is by heating to red heat in a current of dry chlorine a mixture of Cr_2O_3 and C. It forms small violet scales or leaves which when hydrated contain $12\text{H}_2\text{O}$.

3b. CHROMIUM OXYCHLORIDE CrO_2Cl_2 . Obtained by warming alkali chromates with NaCl and H_2SO_4 . A mobile, dark-red fluid which fumes strongly on exposure to air. S. G. at 0° 1.96, B. P. 117° .

4. CHROMIUM CHROMATE, see CHROMIUM MORDANTS.

5a. CHROMIUM FLUORIDE. $\text{Cr}_2\text{F}_6 + 8\text{H}_2\text{O}$, see CHROMIUM MORDANTS.

5b. CHROMIUM OXYFLUORIDE CrO_2F_2 . Prepared like chromium oxychloride. It is a red fuming fluid.

6. CHROMIUM NITRATE. Obtained by treating chromium sulphate with barium nitrate. It is occasionally used as a mordant.

7. CHROMIUM OXIDES.

a) Chromium sesquioxide Cr_2O_3 . This substance is formed by heating the various oxides of chromium to a red heat. Generally potassium chromate is intimately mixed with potato starch and heated in a reverberatory furnace. Calcined chromium oxide is almost insoluble in acids. It is used as a colour. Compare also Chrome green under CHROMIUM COLOURS.

b) Chromium hydroxide $\text{Cr}_2(\text{OH})_6$. Prepared by precipitating chromium salts with caustic alkalies. According to the Amer. Pat. 738239 chromium hydroxide and zinc hydroxide are obtained from the solution of their sulphates by adding CaCl_2 and precipitating the $\text{Cr}_2(\text{OH})_6$ by means of an insoluble carbonate e.g. CaCO_3 ; chromium hydroxide in addition to other uses is employed as a paint.

c) Chromic acid, chromic acid anhydride. CrO_3 . Obtained by the decomposition of $\text{K}_2\text{Cr}_2\text{O}_7$ with concentrated H_2SO_4 . It forms scarlet rhombic crystals M. P. 190° which dissolve readily in H_2O . When exposed to air they deliquesce with formation of chromic acid H_2CrO_4 .

According to the Germ. Pat. 179034 chromic acid may be obtained from the chromates or bichromates of the alkalies by adding sulphuric acid and heating the mixture of chromic acid and bisulphate to fusion. The substances separate into two non-miscible layers so that on cooling the chromic acid can be separated mechanically.

A method for the recovery of chromic acid from solutions of chromium salts by electrolysis is protected by the Germ. Pat. 117949 and 138441. Acid solutions of chromium salts are oxidised by electrolysis. Diffusion neutralizes the effect of change of concentration between the anode and the cathode liquids caused by the effect of the current. One means of doing this is to regulate the current density. Another and better method is to stop the current

occasionally so that during this time the diffusion alone exerts any influence. Chromic acid is used for filling galvanic cells, for dyeing and also as a medicine.

9. CHROMIUM SILICIDE, see SILICIDES.

10. CHROMIUM STEEL, see IRON ALLOYS.

11. CHROMIUM SULPHATE $\text{Cr}_2(\text{SO}_4)_3$. See CHROME MORDANTS.

12. CHROMIUM SULPHITE. Obtained as a neutral salt by dissolving $\text{Cr}_2(\text{OH})_6$ in an aqueous solution of SO_2 or by treating chrome alum or $\text{Cr}_2(\text{OH})_6$ with Na_2SO_3 or as an acid salt with NaHSO_3 or calcium bisulphite with an excess of SO_2 solution.

13. CHROMIUM TUNGSTATE $\text{Cr}_2(\text{WO}_4)_3$. This product is formed as a light-green precipitate on adding an aqueous solution of Cr_2Cl_6 to a solution of potassium tungstate. The precipitate is soluble in an excess of Cr_2Cl_6 , in phosphoric acid, oxalic acid and tartaric acid. If precipitated with ammonium para-tungstate the chromium para-tungstate is formed as a light grey powder soluble in water.

Chromium mordants. Numerous compounds of chromium serve as mordants, that is compounds which enable the fibres to fix dyestuffs. These compounds are partly salts of the chromium oxides, some however are chromic acids, but the latter are only efficacious for the above purpose when reduced to basic chromium oxide salts or to chromium oxide itself.

1. CHROMIUM ACETATE. Obtained as a solution by mixing solutions of chrome alum and acetate of lead.

2. CHROME ALUM. Obtained as a by-product in the manufacture of anthraquinone. Compare ALUMS. By adding Na_2CO_3 or precipitated $\text{Cr}_2(\text{OH})_6$ to a solution of chrome alum a stable basic salt is obtained which is used as a mordant in the same way as chrome alum itself.

3. CHROMALINE. A new chromium mordant has been brought on the market under this name; according to the French Pat. 291471 it is made by the reduction of chromic acid by glycerine or some other fatty compound. Chromaline contains chromic acid in such a loose state of combination that it dissociates if only diluted with H_2O . It is particularly suited for printing chrome colours on wool.

4. CHROMIUM CHLORIDE. By dissolving $\text{Cr}_2(\text{OH})_6$ in HCl neutral chromium chloride is obtained, and by dissolving $\text{Cr}_2(\text{OH})_6$ in CrCl_3 the basic variety of the same compound is formed. Both of these substances serve as mordants for wool-dyeing.

5. CHROMIUM CHROMATE. This product is made by dissolving $\text{Cr}_2(\text{OH})_6$ in CrO_3 . It is principally used for stiffening cotton.

6. CHROMIUM FLUORIDE $\text{Cr}_2\text{F}_6 + 8\text{H}_2\text{O}$. Dark green powder stable in air, readily soluble in H_2O . It has lately been manufactured in large quantities and introduced commercially. It has proved to be a very good mordant.

7. CHROMIUM HYDROXIDE SOLUTION. $\text{Cr}_2(\text{OH})_6$, precipitated by alkalis, dissolves in excess of the precipitant. When cotton or other vegetable fibres are dipped into the solution the $\text{Cr}_2(\text{OH})_6$ is deposited on the fibres in very fine particles. For animal fibres this mordant is not suitable as they are acted upon by alkalis.

8. CHROMIUM SULPHATE. Obtained by dissolving $\text{Cr}_2(\text{OH})_6$ in H_2SO_4 . As in the case of chrome alum, basic salts can be obtained from this substance, and are principally used as mordants.

9. POTASSIUM BICHROMATE $\text{K}_2\text{Cr}_2\text{O}_7$. For the method of manufacture see POTASSIUM COMPOUNDS. It is an excellent mordant, especially for wool.

10. META CHROME MORDANTS. A name given by the Aktien-Gesellschaft für Anilin-Fabrikation to a mixture of potassium bichromate and ammonium

sulphate. Special mordant azo-colours (meta chrome dyes) for wool are rendered very fast by the addition of this mordant to the bath.

11. Sodium bichromate $\text{Na}_2\text{Cr}_2\text{O}_7$. For method of manufacture see SODIUM COMPOUNDS. This substance is used for the same purposes as potassium bichromate and often serves as a substitute for the latter being cheaper in proportion to its chromium content.

Chromium steel, see IRON ALLOYS.

Chrome Tanning, see MINERAL TANNING.

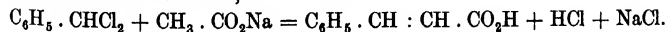
Chromotrope acid, see NAPHTHOL DERIVATES.

Chrysarobin. Is a constituent of the Brazilian tree *Andira Araroba Aguiar*. The crude chrysarobin found in the cracks and hollows of the wood, is at first yellow; later it becomes brown to violet. In order to purify it it is boiled with benzene and the filtrate is then evaporated to dryness and the residue recrystallized from glacial acetic acid. It is a yellow powder, most irritating to the skin and mucous membranes. It is absorbed by the skin and is used for outward application in various skin diseases.

Cineol (Eucalyptol). Cyclic terpene alcohol of the composition $\text{C}_{10}\text{H}_{18}\text{O}$, which frequently occurs in essential oils, especially in eucalyptus oil, cajaput wood oil, wormseed oil, &c. The starting point for the preparation is wormseed oil and eucalyptus oil; from the latter the parts which distil between 175° and 180° are removed according to WALLACH by fractional distillation, the remaining liquid is then cooled and dry HBr gas passed in. The crystalline cineol hydrobromide precipitated is pressed at a low temperature and then distilled with steam. According to the Germ. Pat. 80118 cineol may be obtained from eucalyptus oil by the action of phosphoric acid, according to the Germ. Pat. 132606 by the action of arsenic acid (conc. aqueous solution 70°Bé); the eucalyptol gives crystalline compounds with the above mentioned acids which are separated from the oil and distilled with steam, when pure eucalyptol passes over. M. P. — 1° to — 3° ; B. P. 176° . It possesses a smell resembling camphor.

Cinnamic acid. $\text{C}_6\text{H}_5 \cdot \text{CH} : \text{CH} \cdot \text{CO}_2\text{H}$. This acid can be made either from natural sources or it can be synthetically produced. In the first case storax, see *Balsams*, is distilled with excess of caustic soda, when styrol and cinnamic alcohol are set free and sodium cinnamate remains behind. From the residue the acid itself is separated by means of HCl . It is then purified by dissolving in ammonium carbonate solution, precipitating with HCl , and recrystallisation from hot H_2O .

Synthetically it is obtained by heating benzalchloride with sodium acetate in autoclaves to 180 — 200° ,



Cinnamic acid has also been made from benzal diacetate, from benzylidene acetone and finally by heating benzaldehyde with sodium acetate in presence of acetic anhydride. According to Germ. Pat. 53671 the ethyl ester of cinnamic acid is produced as follows: Finely-cut sodium (1 atom), is added to non alcoholic acetic ether (about 5—6 mol.) which has been cooled in ether. Then the benzaldehyde is allowed to flow so gradually into it that the reaction is never too rapid. When all the sodium has disappeared a quantity of acetic acid, in proportion to the sodium is added. The ester is afterwards removed by diluting the mixture with water, the oily layer is removed and dried with calcium chloride, the acetic ester distilled off on the water-bath and the ester

rectified which passes over at 260—275°. The o-nitrocinnamic acid is best obtained by the nitration of this ester.

Cinnamic acid and the o-nitrocinnamic acid obtained from it serve for the preparation of o-nitrophenylpropionic acid (see PROPIONIC ACID) and several artificial perfumes and colours. Cinnamic acid is also used for medical purposes.

It forms colourless crystals readily soluble in hot water and in alcohol, less readily in cold water.

Cinnamon, Oil of. Two kinds are recognized, true oil of cinnamon (Ceylon cinnamon oil, *Oleum Cinnamon ceylonici*) and cinnamon Cassia oil (Cassia oil, *Oleum Cassiae*, *Oleum cinnamomi cassiae*).

The former is obtained from the residues of Ceylon cinnamon bark by distillation with salt-water; it is at first golden yellow, later red-brown and has a delicate odour of cinnamon. S. G. (at 15°) 1.025—1.035; it contains 70—90 % cinnamic aldehyde and a little cinnamic acetate. Cassia oil is obtained from the bark, buds, fruit, leaves, blossoms, &c. of the cassia tree by distillation with water.

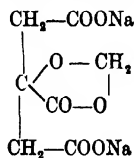
Both essential oils are used for perfumes and liqueurs; Ceylon cinnamon oil is frequently adulterated with cinnamon cassia oil.

Substitutes for cinnamon oil can be prepared in different ways. A synthetic oil can be prepared (Germ. Pat. 134789) as follows:—700 g. cinnamic aldehyde, 10 g. eugenol, 20 g. normal amylmethylketone, 5 g. nonylaldehyde, 3 g. cuminaldehyde, 43 g. caryophyllene, 22 g. linalool, 20 g. linalylbutyrate, 45 g. cymol, 5 g. benzaldehyde, 5 g. phenylpropyl aldehyde, 2 g. furfural, 20 g. pinene and 20 g. eugenolmethyl ether.

A synthetic cassia oil can be obtained (Germ. Pat. 139635) as follows:—550 g. methyl salicylate, 200 g. benzyl alcohol, 80 g. linalool, 12 g. geraniol, 28 g. terpineol, 20 g. ionone, 60 g. irone, 20 g. decylaldehyde and 30 g. cuminaldehyde. Suppl. Germ. Pat. 150170 adds anisaldehyde, eugenol, eugenol-methylether and benzaldehyde to the above mixture.

Germ. Pat. 150501 describes the preparation of an artificial cassia oil in which an alcohol $C_{15}H_{30}O$ (S. G. 0.885; refractive index $n_D = 1.4888$; B. P. — at 10 mm Hg — 160°) is added to a mixture of other substances. (See FARNESOL.)

Citarine. Product of the action of formaldehyde on sodium citrate; it is sodium anhydro-methylene citate

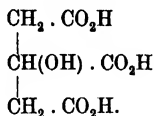


It is a white crystalline powder, very readily soluble in H_2O , which on account of its power of dissolving uric acid, is an excellent remedy for gout. For attacks of this disease doses of 2 g are administered five times on the first day, then diminishing to 4—3—2 times a day. The powder is taken dissolved in water.

Citral (Geranial). $C_{15}H_{26}O$. Terpene aldehyde which occurs in citron oil, eucalyptus oil, lemon grass oil, and can be separated from these with the help of $NaHSO_3$. It can also be obtained by the oxidation of geraniol with $K_2Cr_2O_7 + H_2SO_4$. Citral is the cause of the perfume in citron oil. Of late years it has become an important commercial product, because it forms the starting point for the preparation of Ionone; it may also be used with advantage as a substitute for ordinary citron oil. Liquid S. G. (by 15°) 0.8977; B. P. 228—229°. It may also be mentioned that by a patented process (Germ. Pat. 108395 and 123747) the cyclical isomer, cyclocitral, may be obtained. According to the Germ. Pat. 133758, 139957 and 139958 the two

constituents of cyclocitral, namely the α -cyclocitral and the β -cyclocitral, can be isolated.

Citric acid. A tribasic acid $C_6H_8O_7$, of the following constitution



This acid is obtained from lemon juice by heating almost to boiling point, and precipitating with finely powdered chalk. The rest of the process is exactly similar to that used in the manufacture of tartaric acid (q. v.). The calcium citrate is decomposed with H_2SO_4 and the solution concentrated until the $CaSO_4$ is precipitated. It is then further evaporated. The crude citric acid thus obtained is more or less coloured; it is purified by dissolving in the least possible quantity of hot H_2O , filtering the solution through animal charcoal and allowing it to crystallize. Citric acid has recently been obtained by fermenting grape sugar with special ferments (*Citromyces glaber* and *Citromyces Pfefferianus*). The yield is about 55 % of the grape sugar.

Pure citric acid crystallizes with 1 mol. H_2O ; dissolves at 15° in $\frac{2}{3}$ parts, at 100° in $\frac{1}{2}$ part H_2O . It dissolves with difficulty in alcohol. It gives a precipitate with lime water only on boiling. The potassium salt of citric acid, unlike that of tartaric acid, is readily soluble. Citric acid and its salt are used in dyeing, for medical purposes, and in cooking, confectionery, &c.

Citronellol. $C_{10}H_{18} \cdot OH$. Terpene alcohol which is known in several isomeric forms; it occurs in oil of roses, together with geraniol in other essential oils. It can also be prepared from its aldehyde citronellal, which is found in citronella oil, and is precipitated from this by $NaHSO_3$. Citronellol is one of the chief constituents of rose oil. According to the investigations of TIEMANN citronellol together with geraniol alone accounts for the perfume of oil of roses.

Citrophenone = citric acid triphenetide is made by heating 1 part of citric acid with two parts of p-phenetidine with the addition of a dehydrating agent. The product of the reaction is then washed with very dilute $NaOH$ and recrystallized from hot water.

It is a white crystalline powder which is soluble with difficulty in cold water, but a little more readily in hot H_2O . M. P. 181° . It is used medicinally in cases of fever and neuralgia.

Clarification. The juices of fruits are clarified in a pulp made of filter paper. Also white of egg beaten to a froth is mixed with the liquid to be clarified. The liquid is then heated to boiling point. This is considered an excellent method.

Further, clarifying is carried out by means of isinglass or fish glue, gelatine, or a decoction of boiled calves' feet. This last can be used for any liquid containing tannic acid, for in such the glutinous substance combines with the acid to form an insoluble compound, which in settling carries down the sediments. Those fluids which contain no tannic acid should be treated with it before either isinglass or gelatine is added.

Powders, made from porous earthen-ware utensils, Spanish earth, burnt gypsum, bone charcoal &c. are used according to the solution to be cleared. Burnt gypsum (plaster of Paris) is used for example to clarify essential oils, liqueurs, varnishes and benzine. Burnt alum can also be used for these liquids and for fats.

According to Amer. Pat. 748865, acid liquids such as solutions of glue, are cleared by neutralizing with a suitable base, thereby forming a precipitate, then adding an aqueous solution of SO_2 together with the lime salts of bones, and once more neutralizing to form a precipitate which can then be easily removed.

Another method of clarifying is that of removing the fluorescence from petroleum and other mineral oils. This is carried out by adding α -nitronaphthalene which for this reason has received various names indicating this property. Dead yeast cells are employed, according to the Germ. Pat. 156151 for bleaching and clearing organic substances, which are thus completely or in part freed from their impurities. For this purpose the yeast is stirred up in water, heated *in vacuo* to 50° for several hours, and then warmed with water containing a little HCl to separate the yeast cells from the fluid. After the liquid has been drained off the yeast cells are warmed in a vacuum with weak alkalies and finally thoroughly washed.

Clavine. A substance prepared from *Secale cornutum* which is apparently a definite compound. It is crystalline, soluble in water and has the composition $\text{C}_{11}\text{H}_{22}\text{N}_2\text{O}_4$. It causes power ful "PAINS" without producing inflammation or cramp.

Coalbreakers.

Max Friedrich & Co., Leipzig-Plagwitz 17.

Cast Iron Coal Breakers:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Coal dust. Under this name is known a product obtained by reducing coal to dust. In this form it is used as a special fuel. To ignite a dust-coal fire, the coal dust (with the necessary amount of air) is introduced into the heating chamber, in which the temperature has been raised sufficiently by a wood fire or otherwise. The coal dust then continues to burn and gives an intense flame so long as the fuel is added. For charging the chambers with the coal dust, inventors have made use of the ordinary chimney draught, slightly-compressed air, or some mechanical method of stoking.

In theory the use of coal-dust for heating purposes marks a decided advance. In practice, however, it has had to contend with great difficulties, which are now being gradually overcome. The principal point is that the coal dust must be very fine, for it has been shown that only such coal-dust as leaves no appreciable residue, after being passed through a sieve with 900 holes to 1 sq. cm is of any value for this purpose.

Mills for Coal dust:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Coal gas for lighting and heating purposes. This article treats exclusively of gas made from pit coal. ACETYLENE, ALCOHOL HYDROCARBON GAS, ATMOSPHERIC GAS, OIL GAS and WATER GAS are treated in articles under these respective headings.

Coals which burn well and are rich in hydrogen and contain the least possible amount of sulphur and minerals constituents are used for making this gas. Fire-proof clay retorts round, oval or \cap shaped, with a cross section of 2—3 m and 40—55 cm diameter, are used for the dry distillation of coal. The one end of the retort is closed; at the open end is an iron mouth piece which carries the cover and the outlet pipe. The retorts lie flat or inclined at 30° in the oven and are heated from the outside by coke, tar or generating gas. Each retort is filled with 100 to 200 kg. of coal.

From the mouth piece of the retort rises a vertical pipe which again bends downwards and ends as a dipping pipe in the trough-shaped receiver, which is connected with the whole series of retorts. A great part of the tar and ammoniacal liquor condenses in the receiver forming a trap to prevent the gas from passing back into the retorts during recharging. The retorts must be made red hot — almost white hot. The distillation takes from 4 to 6 hours. Coke remains as a residue in the retorts. This is removed later to make room for a fresh charge of coal.

The tar which is accumulated and concentrated in the receiver comes into the tar reservoir. It is separated from the ammonia water in the receiver by an adjustable apparatus. The gas and vapours which are not condensed pass into the condensers, which cool the gas to 12—15°. In order to prevent the obstruction of the pipes by the naphthalene the cooling must be gradual, for which reason the gas is first sent through an air cooler, which consists of a row of long vertical iron pipes. The gas is forced to pass up and down the pipes of the cooler, after which it passes into a water-cooler the sides of which are surrounded by cold water. The air condenser stands on an iron box provided with dividing walls in which the tar and ammonia water, (further condensed during the cooling) settle. The gas then passes through a so-called *tar separator* which holds back the tar present in the gas in the form of fine drops. To remove the residual ammonia from the gas the latter is sent through a scrubber, containing pieces of coke (or in the newer processes a wooden grating). A fine shower of water falls down the scrubber from above, while the gas passes upwards from below. Several scrubbers are usually placed in a series; or in place of this a more modern washing apparatus, which is more effectual in separating the ammonia is used. After this follows the chemical purification of the gas, which still contains CO_2 , HCN , H_2S , CS_2 and thiocyanates. In purification by lime the gas passes over thin layers of powdered slaked lime which absorbs the CO_2 and H_2S . This process is frequently omitted entirely and the chemical purification is begun with iron compounds. In this process different mixtures are used. The LAMING mixtures used for this purpose consist of equal parts of slaked lime, saw dust and green vitriol. This mixture, on account of the chemical action taking place consists of calcium sulphate, ferrous oxide (which latter is rapidly converted into ferric oxide) and excess of quicklime. The mixture absorbs NH_3 , CO_2 and H_2S with formation of CaCO_3 , $(\text{NH}_4)_2\text{SO}_4$ and Fe_2S_3 . The spent residue is regenerated by atmospheric oxidation with formation of ferric hydroxide from the Fe_2S_3 and separation of S in accordance with the equation $\text{Fe}_2\text{S}_3 + 3\text{O} + 3\text{H}_2\text{O} = \text{Fe}_2(\text{OH})_6 + 3\text{S}$. It has lately been discovered that this kind of material is also effective without the addition of calcium compounds, and substances are now used which contain only ferric hydroxide. As an example we may mention DEICKE's mixture, which is obtained by boiling spent residues containing sulphur with iron filings and then regenerating the Fe_2S_3 thus formed by oxidation. The so-called LUX mixture is highly recommended. It consists essentially of the residues obtained in the manufacture of aluminium hydroxide from bauxite. The ground bauxite is heated with Na_2CO_3 in a reverberatory furnace, and the fused mass is heated with H_2O when the iron is precipitated as $\text{Fe}_2(\text{OH})_6$. The LUX mixture is mixed with $1\frac{1}{2}$ to 2 volumes of saw dust. Oxides containing manganese and the Weldon mud from chlorine stills are also used for the purification of gas. See CHLORINE.

The other methods for the purification of coal gas must be here omitted.

The gas, its pressure having been brought to the desired degree by means of exhaustors and regulators attached to the scrubbers, is now collected in suitable gas holders.

Coal gas which contains too small a percentage of hydrocarbons has a low illuminating power; it is improved in this respect by carburization, that is to say, it is mixed with the vapours of easily volatile hydrocarbons, such as benzene, paraffin oil and petroleum ether. Coal gas can also be carburetted with tar-vapours or by passing it through oil gas.

But few of the new methods of coal-gas manufacture seem to have had much success. Some of the new patents may be here mentioned.

According to the Germ. Pat. 153149 the gas on leaving the retorts is mixed in another retort with some other gas such as water gas. By this means an immediate dilution and cooling take place. This cooling prevents the decomposition of the illuminating constituent on the red-hot walls of the retort, which otherwise takes place to a considerable extent. According to the Germ. Pat. 157470 water gas is allowed to enter, not into an auxiliary retort, but into the actual retort where the gas is made. Opinion as to the merits of admixture with water gas is at present much divided, but the method seems to be increasing in favour. According to the Germ. Pat. 153166, steam is led into the retorts, so that it comes into contact with, and passes through the coal and glowing coke. This method prevents the formation of so much tar and graphite and increases the yield of gas since water gas is formed simultaneously. A modification of this process is treated in the Germ. Pat. 178307. The Germ. Pat. 152374 treats of the separation of the tar from the gas by first adding dust or powdered materials which stick to the tar. By washing the gas later with a current of water the dust and the tar are both precipitated.

Much attention has been attracted by the SETTLE-PADFIELD process in which the work of gas making is carried on in vertical instead of the usual horizontal or inclined retorts. It may be mentioned that these upright retorts were tried in the early stages of gas manufacture. At that time the method was unsuccessful on account of the extensive decomposition which the gas underwent during its circuit through layers of coal from which the gas had not yet been expelled. SETTLE and PADFIELD endeavoured to overcome this difficulty by only partially filling the retorts at first and then automatically adding more, a little at a time so that the gas is removed from the last portion before the new supply of coal enters the retort. All possible advantages are claimed for the new process, though according to some these are over-rated. BUEB in his researches has established the fact that a good yield of by-products can be obtained simultaneously with a gas of high illuminating power.

It is a curious fact that in the coal gas industry it is usually considered desirable to increase the production of tar, while formerly all efforts were made to attain the reverse; a very diminished yield of tar is however obtained in the SETTLE-PADFIELD process, and the Germ. Pat. 155742 protects an arrangement for the decomposition of the tar formed and its transformation into permanent gas.

Of the many new methods of purification, that of FRITZ FRANK for the removal of carbon bisulphide should be specially mentioned. According to this method the removal is carried out by washing the gas with aniline. The initial defect of the process seems to be done away with by using an oil, which consists of tar-oils with a little benzene, a certain amount of basic substances of high boiling point, and only a small quantity of aniline. Free sulphur is added to the washing oil as a catalytic substance, so that the H_2S is converted into diphenylthiourea and held back in this form. Germ. Pat. 157563 employs the oily liquid obtained as a by-product in the distillation of molasses residues as a washing-agent to remove CS_2 and naphthalene from coal-gas. According to the Germ. Pat. 144004 sulphuretted hydrogen, may be removed from gas already freed from ammonia by treatment with ferrous salts to which a copper salt is added in order to accelerate the oxidation. The introduction of this promising method is at present hampered by the

fact, that there is as yet no cheap process known for the recovery of the reduced material.

The Germ. Pat. 159613 protects a mechanically operated apparatus in which gelatinous ferric hydroxide is used to purify the gas. It is scarcely to be expected that such expensive apparatus will find its place in gas works.

Concerning the by-products of gas manufacture, see AMMONIA, GAS LIQUORS, COKE, COAL TAR and RETORT GRAPHITE.

Cooking stoves:

(Gustav Barthel, Dresden-A. 19 (see front part advt.),

Coal Tar. This substance is obtained as a by-product in the manufacture of gas for illuminating and heating purposes. See COAL GAS.

It is one of the most important of the raw materials used in the chemical industries. Since the supply from gas-works is no longer adequate, increasing attention is being paid to its production as a by-product in the making of coke. See COKE.

Coal tar is a more or less dark-coloured oily, viscid liquid with a strong characteristic smell. Its sp. g. lies between 0.954 and 1.220, but as a rule exceeds 1. Some of the chemical compounds contained in this material have not yet been isolated. The following are the most important of the very large number of constituents which have been separated by the distillation of tar.

Fraction.	Mean S. G.	Approximate amount of the distillate	Chief constituents
First runnings from 80°.	0.900 to 0.925	2—3 %	Hydrocarbons of the benzene series. Small quantities of phenols, bases and CS ₂ . Still smaller quantities of hydrocarbons of the fatty series.
Light oil from 170°	0.995 to 1.0	2—3 %	Toluene, xylene, cymene. Phenol (20 %). Naphthalene (25—30 %).
Carbolic oil from 220°	1.015 to 1.025	5 %	Phenols (40 %) including cresols. Naphthalene (40 %) and the higher-boiling hydrocarbons.
Cresote oil from 250°	1.045 to 1.050	20 %	Phenols (15—20 %), chiefly cresols and xylols. Pyridine and quinoline bases (5 %). Naphthalene and other solid hydrocarbons (50 %). Liquid hydrocarbons (aromatic) (25—30 %).
Anthracene oil from 280°	1.085 to 1.095	10 %	Phenols (2—3 %). Anthracene (3 %). Hydrides and homologues:—Phenanthrene, pyrene, fluoranthrene, carbazol, acenaphthene &c. The bulk consists of liquid hydrocarbons not yet investigated.

G. KRAEMER gives the following products and their percentage amounts obtained by the modern methods of treating tar.

Benzene and Homologues	2.50	per cent
Phenol and Homologues	2.00	" "
Pyridine (Quinoline bases)	0.25	" "
Naphthalene (ace-naphthenes)	6.00	" "
Heavy oils	20.00	" "
Anthracene, phenanthrene	2.00	" "
Asphalt (soluble constituents of pitch)	58.00	" "
Carbon (insoluble constituents of pitch)	24.00	" "
Water	4.00	" "
Gas and Loss	1.25	" "

The crude tar, as such, is now made use of in relatively small quantities. It is used as fuel, for painting buildings, for making water-proof roofing-felt, as a disinfectant &c. As a rule the valuable constituents are removed by distillation and the residue, pitch, is reconverted into a tar by mixing with the cheap heavy oils. This mixture is just as useful for the above purposes as the valuable raw material. See TAR OILS.

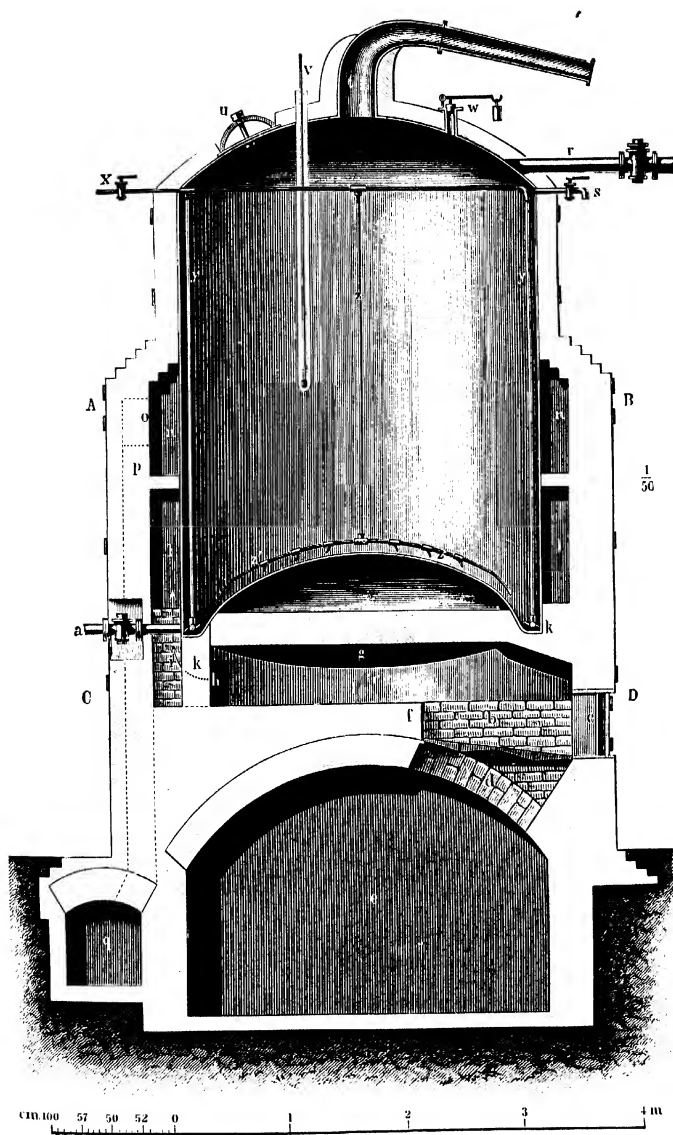
Before being further worked up the tar is often separated by filtration from the suspended carbon, which often amounts to 30 % or more. See SOOT.

Distillation is used for the separation of the constituents of coal tar and also for their purification. Generally the distillation is carried out in wrought iron stills of various forms; these often take the shape of vertical cylinders. The heating is carried out either over the direct-flame or by means of super-heated steam. The first distillation is mainly intended to separate the volatile from the non-volatile constituents (pitch). To avoid violent bumping during distillation, the water floating on the tar is removed and the tar is very slowly warmed so that the water may first evaporate.

The fact that the water present in the tar renders the process of distillation more difficult because of bumping and frothing and so rendering the distillate impure, has led to many new methods for drying the tar before the process of distillation is begun. Two of these methods deserve special notice.

According to one employed in RUTGEE'S WORKS (Germ. Pat. 161524, the drying of the tar before distillation is carried out in a common tar boiler which is heated by the waste heat from the still proper. Three such boilers form a system. The SCHOLVIEN process Engl. Pat. 12696 (1903) depends upon the fact that the water may be removed by the addition of burnt lime or gypsum, after which treatment the tar can be distilled in the usual way after the hydrates formed by the above named substances have been removed. In the distillation proper the H_2O still contained distils over first. After the water, the light oils come over. All the products are condensed in a worm and run thence into a receiver. At the beginning of the distillation it is well to cool; later the condensing water must be kept warm in order that the less volatile fractions may not solidify in the pipe, and so cause the choking and bursting of the apparatus. When the distillation is finished, the residual liquid pitch is run off at the bottom of the still. The separation of the fractions of high boiling point can be accelerated by the introduction of super-heated steam. The cover of the still contains a thermometer. Behind the cooling pipe there is attached a separating apparatus for diffusing, which permits the various fractions to be separated into light and heavy oils (and also the light oils from the H_2O which comes over at the same time). The stills hold as much as 25 tons of tar. For this quantity the distillation takes, on an average, 46 hours. Thirty hours are occupied in obtaining the first runnings, 2 hours for the light oil, 3 hours for the carbolic oil, 7 hours for the creosote oils and 4 hours for the anthracene oil.

The process of distilling coal tar has undergone considerable modifications, the principal one being that the first distillation is now carried out under reduced pressure. A better separation of the fractions is thus attained and the decomposition of the valuable constituents is less than in the old process. The further fractionation is also carried out under diminished pressure in a column apparatus. A new method for the distillation of coal tar involving the use of very low pressures is protected by the Germ. Pat. 153322. The distillation of the tar in apparatus with internal heating arrangements is intermittent. It is carried out in cylinders with a large number of narrow heating pipes (as in locomotive boilers). The pressure is gradually lowered so that at



A COAL TAR STILL

the end of the distillation the temperature of the tar is not more than 270–280°.

Finally, mention should be made of LENNARD's process, which is based on the distillation of super-heated tar with super-heated steam followed by fractional condensation.

The following remarks apply to the various fractions of tar distillation.

The first runnings, also called light naphtha, contain besides the more volatile of the tar some of the heavier constituents in varying proportions. The first runnings are treated with caustic soda when the phenol is separated as sodium phenolate which can be easily drawn off from the layer of oil above it. The oil is then treated with conc. H_2SO_4 , which sinking to the bottom of the still carries down with it the impurities in the form of resins. The naphtha, thus partly purified, is then fractionated over an open fire, and three fractions up to 110°, 140° and 170° respectively are collected. The rectification of these fractions is afterwards accomplished by distillation with direct or indirect steam heating. The light oil contains some benzene, a good deal of toluene and its homologues, and in addition phenols, naphthalene &c. Good light oil should not lose much by distillation below 120°. The principal part should distil below 170°. Average S. G. 0.975. The light oil is then separated by distillation into 3 fractions of which the first is worked up with the first runnings while the fraction distilling above 170° is worked either alone or with the carbolic oil. The middle fraction is purified like the light-naphtha with acids and alkalies and then again distilled. For the fractions thus obtained see BENZENE and SOLVENT NAPHTHA. By repeated rectification of these fractions in the column apparatus it is finally possible to separate the different hydrocarbons in a pure state.

The further treatment of the next fraction of coal tar, carbolic oil, which comes over between 220° and 250°, is described in the article on CARBOLIC ACID and NAPHTHALENE.

The heavy oil proper, the CREOSOTE OIL, that is the fraction 250°–280°, is usually left in this condition without further treatment, and is used for making oil-gas, as a lubricant, for carburetting coal gas, for the manufacture of lampblack, for softening pitch, for pickling wood, as a disinfectant as well as for making other disinfectants, such as creolin and lysol. The heavy oil which is mixed with the other coal tar fractions is a thick, oily, yellowish-green, fluorescent fluid, with a most unpleasant and characteristic smell. S. G. 1.05.

The highest-boiling fraction is anthracene oil. For details of the treatment of this substance, see ANTHRACENE. This oil is chlorinated to remove the smell. Compare CARBOLINEUM. The pitch which remains after the distillation is either treated with heavy oils to make „tar“, or it is brought into the market in this condition. See PITCH.

TEST. The analysis of crude tar includes a determination of the specific gravity, the amount of uncombined carbon and also a distillation test.

To determine the specific gravity, the tar must first be dried. For this purpose it is placed for 24 hours in a large covered beaker immersed in warm water, the temperature of which must not exceed 50°. The water which has meanwhile collected on the top is then removed, either by decantation or by absorbing it with blotting paper. The separation is helped if now and then the glass is tapped on the outside, while in the warm water. The dry tar is then poured into a pycnometer through a funnel and the S. G. determined at 15° C.

For the determination of the uncombined carbon, KÖHLER, *Dingl. Polytechn. Journal* 270, Page 333, gives the following directions; 10 g of coal tar are mixed with 25 g of glacial acetic acid and 25 g of toluene in an Erlenmeyer

flask fitted with a reflux condenser and brought to boiling point. The liquid is then filtered through two tared filters one inside the other and washed with hot toluene until the latter is no longer coloured. The C is then obtained perfectly free from tarry matters, and the amount of uncombined carbon in the sample can be found from the difference of the weight of the two filters after drying at 120° until constant in weight. A normal coal tar contains about 16 % of free carbon.

The sample for distillation is treated according to the method given by LUNGE and SCHMID, Chem. Ind. 1887, P. 337, as follows. Tubulated retorts holding about 5 litres are used. These are half filled with the dried tar and heated in a sand bath. In the tube of the retorts is fitted a cork with two holes. Through one of these the thermometer passes and through the other a glass tube drawn out to a capillary which projects half way into the liquid. If a gentle current of air is drawn through the capillary tube during distillation bumping is prevented (according to ANSCHÜTZ). As long as the distillate remains fluid, the neck of the retort is connected by an adapter to a LIEBIG condenser, which however must be removed and replaced by a receiver directly the distillate solidifies (170 — 180°), from which point onwards it is also no longer necessary to draw air through the capillary tube. The distillation of 2.5 to 3 liters of tar takes about 8 hours. It is absolutely necessary that there should be no interruption, if the results are to be trustworthy. It is also important that the water mechanically added should be removed before distillation. The following fractions will be found in the receivers. 1. light oil up to 170° , 2. middle oil up to 230° , 3. heavy oil up to 270° , 4. anthracene oil till the substance distilled changes its colour and becomes an intense orange due to presence of large quantities of chrysene. To test the light oils further, 200 ccm are put in a separating funnel with 20 ccm H_2SO_4 of 66° Bé and shaken vigorously for five minutes. The tarry sulphuric acid is then carefully drawn off from the dark coloured oil above it, after which the latter is washed twice in the funnel each time with 30 ccm H_2O . This is followed in the same way by treatment with 30 ccm of caustic soda of S. G. 1.060 and then again with 30 ccm H_2O . The volume of the oil remaining is then measured in a graduated tube, and the difference between this and the original is calculated as loss by purification. The purified oil is fractionated in the way given in the test in the article on BENZENE. The product of distillation up to 120° consists principally of a mixture of benzene and toluene, the product occurring between 120 and 170° is considered as solvent naphtha and the residue of the distillation remaining in the glass is called creosote oil.

The middle oil and the creosote oil are allowed to stand several days to allow the naphthalene to separate. The naphthalene is then filtered off, the residue wrapped in a linen cloth and pressed out in a small hydraulic press. The naphthalene obtained by pressing the residue of the two fractions is reckoned as crude naphthalene. After the separation of the naphthalene from the middle oil, the latter is fractionated in the same way as the light oil.

The anthracene oil is allowed to stand for 3—4 days. It is then filtered through linen, the crude anthracene is pressed out cold, if necessary warmed on porous clay plates to 30 — 40° and then again pressed, and reckoned as crude anthracene. The residue in the retort after the distillation of coal tar is reckoned as pitch. Its amount is usually calculated from the difference between the amount of tar used and the sum of the products of distillation.

Cobalt. Co. A. W. = 59.6. The most important cobalt ores are cobalt glance $\text{CoAs}_2\text{CoS}_2$, speiss cobalt CoAs_2 . It is almost invariably obtained simultaneously with nickel by wet or dry processes or by a combination of the two. See also NICKEL. To separate the two metals, the solution may be treated with potassium nitrite which precipitates the cobalt. More fre-

quently however, the Co is precipitated as Co_2O_3 (after removal of the Fe), from neutral warm solutions with bleaching powder. In this reaction Mn and Ni are also precipitated, the former before and the latter after the Co, so that separation is possible. Here we can only refer to the Germ. Pat. 151955 which treats of the separation of the Ni and Co from each other, and of the separation of other metals. The metal is obtained by heating the chloride or hydroxide to a red heat in a current of hydrogen or (commercially) with powdered charcoal. It occurs as a grey powder or in crystalline leaves of a reddish colour with metallic lustre. S. G. 8.5. It is harder than iron and melts at a slightly lower temperature. Large pieces have been cast only recently. By adding a trace of Mg a very hard metal is obtained, which can be easily wrought while hot, and is capable of taking a very high polish. In this form it is sometimes used for making cutting instruments (e. g. fruit knives). The compounds are of greater importance.

Cobalt alloys. As already remarked in the article on COBALT, this metal is coming into use in the form of alloys. It is used in jeweller's work in two forms:—

SUN BRONZE which consists of 40—60 % Co, 30—40 % Cu and 10 % Al.

METALLINE, which is made of 35% Co 30 % Cu, 10 % Fe and 25 % Al.

Cobalt colours. 1. **SMALT**, (ROYAL BLUE, SAXON BLUE, &c.). This, the most important of the cobalt colours, is made from the roasted cobalt ores. Smalt is a potash glass coloured a deep blue by cobalt oxide. It is made by melting potash and silicic acid (quartz sand), together with roasted Co ores. The purest kinds can only be made from pure cobalt oxide. The smalt (cobalt potassium-silicate) is poured while in a liquid condition into cold water, and so becomes very brittle and easily powdered. The glass is pounded and then ground under water, it is then sorted according to the size of the grains. The coarsest powder, called strewing smalt, is usually fused again. There are also obtained the so-called colour and the finest kinds which are called ash blue, pale smalt and zaffer. The commercial kinds are F (fine), M (medium), O (ordinary), while doubling of the letter signifies a finer product. The quality is reckoned by the size of the grains, the cobalt content, and the depth and purity of the colour. The products which contain the largest quantity of cobalt are known under the name of azure blue and royal blue.

Cobalt blue is a fairly stable colour which has been partly replaced by ultramarine. It has however held its own as a colour for china painting.

2. **COBALT BLUE** (COBALT ULTRAMARINE, THENARD'S BLUE, LEITHNER'S BLUE, LEYDEN BLUE) is a clay containing cobalt, which is obtained by heating cobalt compounds and clay to a red heat. It is obtained by precipitation of a cobalt salt with an aluminium salt solution. The precipitate after being dried is heated to white heat.

The depth of the colour depends upon the proportions of aluminium and cobalt salts.

3. **COERULEUM** (SKY BLUE). A cobalt-tin oxide very stable in air. It is prepared by treating tin with HNO_3 , adding a solution of cobalt nitrate, evaporating to dryness and heating to a red-heat.

4. **RINMANN'S GREEN** (COBALT GREEN). A mixture of Co and Zn oxides obtained by precipitation of solutions of cobalt and zinc salts, heating the precipitate (at a lower temperature, however, than in the case of cobalt blue). By the addition of small quantities of arsenic acid or arsenic-cobalt compounds a very beautiful green is obtained.

5. **COBALT YELLOW** (INDIAN YELLOW). Potassium cobaltinitrite, precipitated by potassium nitrite in the form of crystals from a solution of cobalt nitrate made strongly acid with acetic acid. It is more frequently used as a yellow

colour for painting in oils and in water colours where pure tints are desired than as a colour for glass or china painting.

6. COBALT RED OR COBALT ROSE see No. 2 c under COBALT COMPOUNDS.

Cobalt compounds. The salts of nickel are all green while those of cobalt are of a red or blue colour.

1. COBALT CHLORIDE, CoCl_2 , obtained by dissolving CoO in HCl . Dark red crystals, $\text{CoCl}_2 + 6 \text{H}_2\text{O}$, which on heating lose the water of crystallization and become blue.

2. COBALT OXIDES.

a) COBALTOUS OXIDE, CoO , obtained by heating cobaltous hydroxide to a full red-heat in the absence of air. It is obtained as a brown powder.

b) COBALTOUS HYDROXIDE, $\text{Co}(\text{OH})_2$, obtained as a rose-red precipitate by the addition of alkalis to solutions of cobalt salts in the absence of air. When exposed to the air it readily oxidizes.

c) COBALT OXIDE, Co_2O_3 , obtained pure in the form of a dark-brown powder by gently heating cobalt nitrate to a dull red heat. Cobalt hydroxide $\text{Co}_2(\text{OH})_6$ is precipitated as a black powder from Co salts by a solution of bleaching powder.

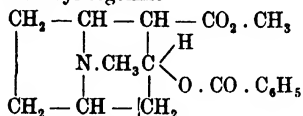
3. COBALT SILICATE see SMALT under COBALT COLOURS.

4. POTASSIUM COBALTNITRIDE, $\text{Co}_2(\text{NO})_8 + 6\text{KNO} + 3 \text{H}_2\text{O}$. Compare COBALT YELLOW under COBALT COLOURS. Potassium cobaltinitride is of importance in analytical chemistry, for the quantitative separation of Co and Ni .

Cobalt compounds:

Willy Manger, Dresden, Germany.

Cocaine. $\text{C}_{17}\text{H}_{21}\text{NO}_4$ is an alkaloid which is obtained from the leaves of the coca plant. Its constitution may now be considered as definitely known. It is the methyl ester of benzoyl-ecgonine



The investigation of the constitution is of practical importance since other alkaloids with very unpleasant action also occur in the coca leaves which like cocaine may be converted into ecgonine by heating with hydrochloric acid. Pure cocaine can then be prepared synthetically from the latter compound.

The alkaloids may be prepared from the coca leaves in the following manner: The leaves are first moistened with Na_2CO_3 solution and then extracted with mineral oils (benzine or petroleum, kerosene, &c.): the alkaloids are then extracted from these oils by means of dilute sulphuric acid, precipitated from this acid solution by sodium carbonate, and the crude cocaine filtered off and recrystallized from alcohol. It is finally purified by converting it into the hydrochloride.

Pure cocaine forms large colourless crystals of bitter taste, *M. P.* 98° . It is very sparingly soluble in water, readily soluble in alcohol, ether, benzene, chloroform, turpentine oil, &c., &c. With acids it forms monovalent salts. On account of its property of temporarily paralysing nerve-endings it is of great importance as a local anaesthetic. For painting mucous membranes a 10–20% solution of cocaine hydrochloride is used; for injections a 5–10% solution, and for washing the eyes a 2–10% solution of the same substance. Maximum single dose 0.05 g. Maximum daily dose 0.15 g.

Cochineal. A colouring matter prepared from the bodies of the females of *Coccus cacti*. The wingless females are collected from the leaves of different kinds of Cactus plants, killed by the action of boiling water, steam or dry heat, and are then brought into commerce in the form of oval particles 1 to 2 mm. long. According as the wax on the insect has been preserved or destroyed the cochineal is "silver-grey" or "black". The colouring matter present is carmine or carminic acid.

In addition to the cochineal above described a preparation is sold as **CARMINE**. This is a red dyestuff occurring in the form of a soft powder or in pieces, which is obtained by the precipitation of cochineal solutions with acids or acid salts. The exact mode of procedure is kept secret but carmine is generally the calcium aluminium albuminate of carminic acid. Cochineal is also prepared in the form of lakes (Florence, Vienna or Paris lakes). For the preparation of these, alkaline solutions of cochineal are precipitated with alum or with a mixture of alum and tin salts. By digesting cochineal with ammonia in the absence of air and precipitating the solution so obtained with aluminium hydroxide *Cochenille Ammoniacale* is obtained. This is sold in the form of dark-brown tablets. Cochineal is also compressed in a form suitable for culinary purposes.

Carmine and carminic acid are used both as oil- and water-colour paints. It is occasionally used for the dyeing of wool with the addition of aluminium or tin mordants.

Cocoa. The seeds (beans) of the cocoa tree *Theobroma cacao*.

A distinction is made between retted, and unretted cocoa. The latter which is only dried in the sun has a strong bitter taste. The process called retting consists in letting the beans ferment for some days and then quickly drying. This gives the cocoa a milder taste. (The germinating power is of course destroyed). The quality of the cocoa depends on the country where it is grown and on the method of preparation. The active principle of cocoa is theobromine, (dimethylxanthine) which is contained in the beans to an extent of from 1 to 3 %. Besides this the shelled beans contain 10—12 % proteid substances and about 50 % oil (cocoa butter).

The commercial product called cocoa, from which chocolate is made is the result of somewhat complicated operations. It is first sifted and sorted so as to remove all refuse. Then it is roasted in rotating iron drums, put into a crushing mill and broken, and the shells separated. After being once more sifted the broken beans are put into a crushing mill with vertical runners, or some other kind of specially constructed mill, where they are ground to a fine powder. The crushing mill is at the same time treated with steam. The powdered mass is now ready for making chocolate. See CHOCOLATE. In case the powdered cocoa bean is to be further manufactured into cocoa, the powder is put into bags and placed in hydraulic presses heated with steam. The oily contents (cocoa butter) are then run off leaving the cocoa in a dry state.

The powdered cocoa contains 50—55 % of oil before being pressed, after the process, if this is well carried out, it contains only from 20—35 %.

As the dry powder of the cocoa thus obtained only becomes miscible with water after long boiling it is usually digested with a solution of potassium or sodium carbonate (Dutch method), or a solution of ammonium carbonate is added. The powders treated with these chemicals are the so-called easily soluble cocoas and to these a small proportion of the oil is again added before sale.

Machines for manufacturing Cocoa:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Cocoa nut butter. For this preparation the cocoanut oil derived from the first pressing is used. It forms a yellow or yellowish oil which is decolourized with animal charcoal or fuller's earth. The following processes are of importance so far as the further purification and rendering the taste more palatable are concerned:— treatment with high-pressure steam, neutralizing with magnesia, precipitating the excess of the latter and the resulting magnesia soap, washing with warm water, and remelting.

According to the Germ. Pat. 143946, the peculiar taste and odour of cocoanut may be removed by neutralizing the cocoanut oil — which has been previously treated with animal charcoal, fuller's earth or kieselguhr — with a solution of lime, and then heating the mixture to 105° in autoclaves. On the other hand it is recommended to remove the bitter substances by washing the cocoanut oil with dilute H_2SO_4 , then adding a weak solution of sodium carbonate to the oil, and finally neutralizing it in the melted state with $Ca(OH)_2$.

Finally, according to a French patent, the cocoanut oil is neutralized at 30° with a solution of water glass, and the resulting soap allowed to stand, while the neutral oil which swims on the surface is drawn off.

Pure white, transparent, lard-like mass; M. P. 26.5°. Solidifies at 19.5° C., possesses a slight pleasant odour with a mild non-irritating taste. It keeps very well and does not readily become rancid.

Cocoa nut oil. This is a fatty oil obtained by pressing out the kernels (copra) of the cocoanut palm *Cocos nucifera*. The copra contains between 60 % and 70 % of this substance. It is not a definite body but a mixture of different fats. This accounts for the fact that the cocoanut oil obtained by moderate pressure and only slightly warming is harder than that prepared by employing greater heat and considerable pressure.

It is a white or yellowish buttery mass which has a characteristic sweet smell—especially on being heated. M. P. 24.5° (varies between 20° and 28°). Melting point of the fatty acids 24.6°. Saponification number 255, iodine number 9.

Cocoa nut oil is used largely for the manufacture of toilet soaps. The saponification may be carried out at a temperature of 70—80° C. (cold saponification). The soap is not precipitated by common salt and for this reason it can be used for washing with sea water (marine soap). Further the cocoanut oil is used in the manufacture of candles, and as a foodstuff after it has been submitted to special purification; compare "COCOA BUTTER".

Codeine see „OPIUM AND OPIUM ALKALOIDS“.

Coeruleum, see "COBALT COLOURS“.

Coffee essence. The substance known under this name is composed of various kinds of sugar which are burnt in special ways, together with suitable aromatics and „fillings“. It is used to cheapen coffee. On account of the high degree of hygroscopicity of the caramel it is best preserved and transported in tin cans.

Cognac, oil of, oenanthylic ether. A mixture of different esters. What is brought into commerce under this name is partly the rectified wine fusel oil and partly an artificial grape oil. The former is obtained by collecting the dregs from the fermentation of grape juice, pressing out the greater part of the water, slightly acidifying with sulphuric acid, mixing with water to a thin paste, and then distilling with steam. The oil which passes over is treated with ten times its volume of water; and is then insoluble in water but readily soluble in alcohol, and gives the latter the taste and smell of cognac.

Artificial cognac oil is manufactured in various ways, as for instance, by the saponification of cocoanut oil, decomposition of the soap with sulphuric acid, adding alcohol to the mixture and distilling. Further it is also made from pelargonium oil and from castor oil. Since the naturally occurring grape oil is very dear the manufacture of the artificial product is carried out on a large scale.

Coke. Coke is the residue obtained in the dry distillation of coal and also of brown coal. Compare CHARCOAL and CHARCOAL BURNING. The coking is now but rarely carried out in open ovens, generally in retorts, so that the by-products may be recovered. The gaseous products are frequently used for heating the retorts.

The products of distillation consist of about 30 % of liquid and 20 % of gaseous substances in addition to the residual coke. See the article on COKING.

According to the nature of the coal from which the coke is made the product has different characters. When prepared from a coal containing a large amount of siliceous matter the coke is loose and granular. From certain other kinds of coal the coke obtained is fused together and forms a more or less solid mass.

It burns without flame, and, apart from its use for household purposes it finds its largest use in blast-furnaces and metallurgical processes.

Concerning the composition and heating value of coke see FUEL.

Cokebreakers:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Coking. Formerly the dry distillation of coal was only carried out for the purpose of obtaining the residue viz. the coke. For this purpose open heaps, ovens and retort furnaces could be used without any consideration of special construction. Still some conditions for carrying out the work had to be fulfilled in order to meet the requirements occasioned by differences in the coal.

The greatest quantity of coke is used for blast-furnace work. For this purpose, a fuel is necessary consisting, as far as possible of pure carbon containing no volatile constituents. The coke for smelting works must be as dense as possible. These qualities were not found in the coke from the gas works — indeed gas coke is almost useless for metallurgical purposes, principally because of its sponginess. To avoid the formation of pores in the coke the gas from the coal must be allowed to remain in contact with it for a longer time than is possible when the principal object is the manufacture of coal gas.

Although it is therefore necessary to manufacture coke, apart from that produced in gas-works, there is still no question of again using the old fashioned method of distillation in piles or open furnaces since the useless waste of the products of distillation would represent an enormous loss of money. Further, a new factor has come into consideration which forced the adoption of a new method for obtaining coke, the fact that the chemical industry demands ever increasing quantities of coal tar and the products of its distillation. Indeed the demands are so great that the gas-works can no longer meet them.

All these circumstances led to the production of coke by dry distillation, which has practically done away with the older methods. The coal for the production of coke is freed from gas at as high a temperature as possible, using the regenerating method of heating. The gases are drawn off and led back into the coke furnace for heating purposes. In order that the coke may acquire the required compactness, the coal is built up in high piles so that the lower layers are pressed down by those above. This prevents the formation of the spongy coke which results in the manufacture of coal gas where the coal in the retorts is spread out in thin layers.

Before the gas given off from the retort is used for heating, the valuable constituents such as ammonia, tar and benzene are separated.

The separation of the gas water, the ammonia water, and the tar is carried out generally by the same methods as in the manufacture of coal gas. Compare COAL GAS. The recovery of benzene from the gases of the distillation of coal is of special importance. This product must not be removed from gas which is to be used for illuminating and allied purposes since it forms the most important constituent as regards the illuminating power of the gas flame. Indeed coal gas is sometimes carburetted by the addition of benzene vapours to increase the intensity. Benzene is however of no importance as a heating agent and its presence is consequently no loss in distillation for the preparation of coke, in which the heating value alone is the determining factor.

There are several methods for separating the benzene from the other gases obtained in the manufacture of coke. Either the benzene is separated from the gases by means of cooling machines, or the gases are washed according to BRUNCK's method, with oils of high boiling point which retain the benzene. The Bulmke Coal Distillation Company wash the gases for the purpose of retaining the benzene in the same way as BRUNCK, that is with a tar-oil of high boiling point, but employ simultaneously a cooling machine which keeps the tar-oil at 1° to 0° C. This modification has been adopted since it was discovered that the benzene is the more perfectly retained by the tar-oil the colder the latter is kept.

On the further treatment of the tar thus obtained compare COAL TAR. The apparatus used for the distillation of tar in order to remove the light oils is also employed for regaining the benzene absorbed by the washing oils.

New patents dealing with this subject are:— Germ. Pat. 171901, 171203, 174695 and 176365.

Colanine. A glucoside contained in kola nuts which splits into caffeine, kola red and sugar under the influence of ferments. 1 part colanine is equivalent to 14 parts of the fresh kola.

Colanine, which separates into its ingredients under the action of the saliva, is an excellent stimulant and is used for many complaints, especially for lassitude, and the heart weakness of neurasthenia. It is given as tincture, in the form of pills, lozenges and tablets, made with extracts of colanine.

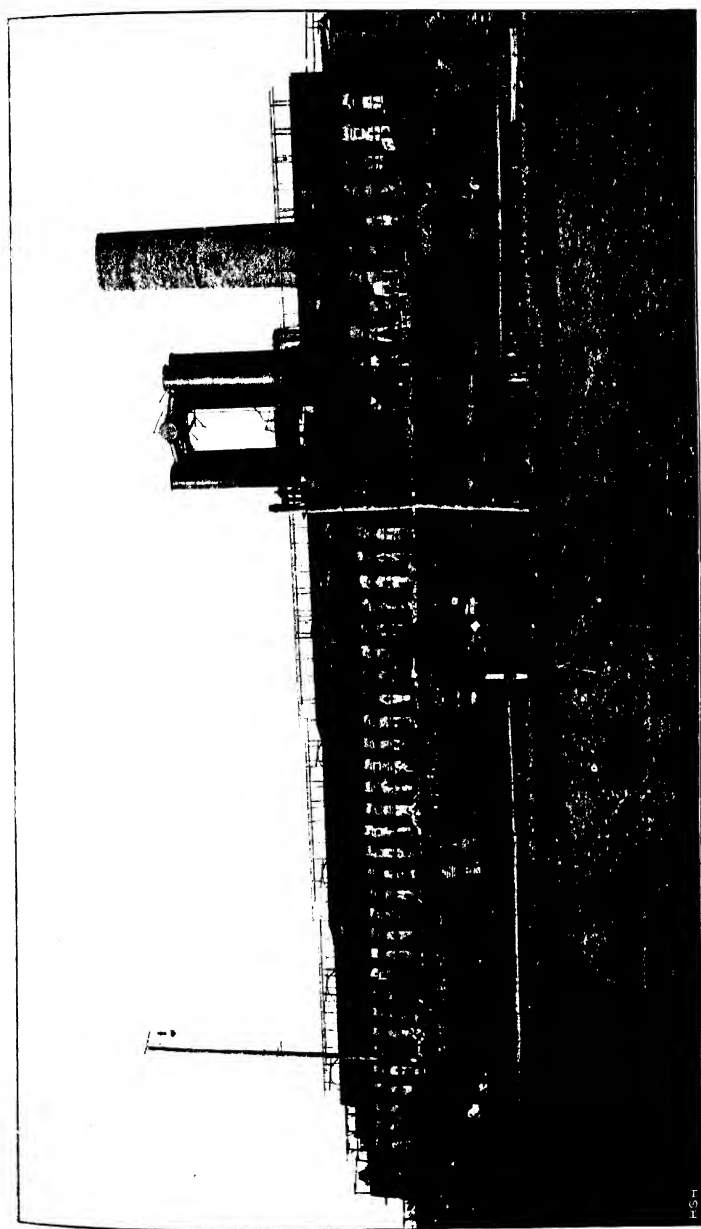
Colchicine. $C_{22}H_{25}NO_6$. Alkaloid of *Colchicum autumnale*. It is prepared by extracting the whole colchicum seeds with strong alcohol, evaporating the solution, mixing the residue with a large amount of water, filtering, and extracting the colchicine from the filtrate by shaking it with $CHCl_3$. The colchicine is then obtained by distillation in the form of colchicine-chloroform.

The alkaloid itself is brought into commerce in small yellow plates or as a whitish yellow powder. It is readily soluble in water, alcohol, and chloroform, and only sparingly soluble in ether. M. P. 145° .

Colchicine is a deadly poison; it is prescribed — in the pure state and in the form of its salts — but only to a comparatively slight extent for gout and rheumatism.

Collargol (ARGENTUM COLLOIDALE). Colloidal silver (also called CREDE's silver) may be prepared by allowing a solution of iron citrate to act on a dilute solution of silver nitrate under certain conditions, and washing the resulting precipitate with a dilute solution of sodium citrate; it is then dissolved in water and precipitated with absolute alcohol.

When moist, it forms a lilac, blue or green coloured mass; when dry it is black and possesses metallic lustre; it dissolves in water (1:20) to form a dark-brown solution.



BATTERY OF COKE OVENS WITH RECOVERY OF BY-PRODUCTS: BRUNCK SYSTEM

It is used in medicine for very many septic diseases, especially externally in the form of collargol ointment (*Unguentum CREDE*). This is called the silver-smear cure. It is also used in the form of tablets particularly for the treatment of wounds.

Collaurin. Colloidal gold is prepared in a similar manner to colloidal silver; compare article on "GOLD" and "COLLARGOL". It is said to find employment in medicine in the treatment of syphilis, scrofula, and cancer.

Collodion and Collodion wool. The latter product is a dinitrocellulose. For its preparation pure cotton wool is nitrated with potassium nitrate and H_2SO_4 or with HNO_3 and H_2SO_4 . For nitrating 1 kg of cotton wool a mixture of 20 kg H_2SO_4 and 9 kg KNO_3 is used. The cotton wool is allowed to remain in the acids until a sample slightly washed with H_2O and then with alcohol easily dissolves in a mixture of 2 parts of ether and 1 part of alcohol. MANN gives the following method. A mixture of 31 parts of concentrated H_2SO_4 and 20 parts of powdered KNO_3 is used. The reaction is carried out at a temperature of $28-30^\circ\text{C}$. and the cotton wool is allowed to remain 24 hours in the mixture although the nitration is finished much sooner. If a mixture of both acids is used, the temperature of nitration must not exceed 8°C . A mixture of 89 parts of HNO_3 , S. G. 1.424, and 104 parts of H_2O , S. G. 1.833, is used.

The collodion wool (dinitrocellulose) is first washed with cold H_2O until no longer acid, then in boiling H_2O and finally dried at a moderate temperature.

For the purpose of removing the acid and rendering it stable the collodion wool (according to Germ. Pat. 150319), is while still wet placed in a hydro extractor into which dry super-heated steam is allowed to enter. When the steaming process is ended, the collodion wool is washed, first with hot and then with cold water in the drum, while the latter is still in motion. For the preparation of collodion, the collodion wool is dissolved in a mixture of 2 to 3 parts of alcohol and 15-20 parts of ether. The solution forms an almost colourless, viscid liquid, which on drying leaves a colourless unbroken skin.

Collodion wool is used for the preparation of CELLULOIDINE, CELLULOID, and BLASTING GELATINE. Compare the articles on CELLULOIDINE, CELLULOID, and DYNAMITE. Collodion is principally employed in photography and medicine.

Collodion and Collodion Wool:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin.

Colloidal Bodies. Numerous recent experiments have proved that there are many metals which can be obtained in a form soluble in water. These metallic colloids or hydrosols are probably not really entirely solutions, but contain the metal in a very fine state of suspension. The property of forming colloidal solutions was first studied accurately in the case of Au and Ag and of metals which can be readily reduced. The colloidal form results when the reduction takes place in very dilute solution. For example colloidal silver is obtained in the form of blue or red solutions by reducing very dilute AgNO_3 solution with FeSO_4 in presence of some organic acid such as tartaric or citric acid. A very interesting method for producing colloidal metallic solutions has been discovered by BREIDIG. He allows electrodes of the metals in question to disintegrate under water and thus obtains liquids of a deep colour in which the metal is dissolved in its elementary form.

BREIDIG's method yields metallic hydrosols of great purity, but the purely chemical methods have also been greatly improved. A very lasting deep blue solution of gold can for instance be obtained by reducing neutral AuCl_3 solution 1 : 1000 with hydrazine hydrate 1 : 2000. PAAL's method for obtaining colloidal gold is to take 4 parts of protalbinic acid dissolved in

24 parts of 5 percent aqueous sodium hydroxide, and 1.7 parts of chloride of gold, also dissolved in water. On warming on the water bath a red colour will appear and gradually, on further addition of sodium hydroxide solution this will disappear. The liquid is opaque in reflected light but is deep red by transmitted light (if observed in thin layers). It is purified by dialysis in a current of distilled water, and the contents of the dialyser are concentrated on the water bath and after this the gold preparation is precipitated in heavy dark red scales by pouring the solution into several times its volume of alcohol. The precipitate after being dried in a vacuum changes into a dull brownish-violet mass. It is worthy of note that this preparation will readily and completely dissolve in H_2O after being kept for several years, yielding a beautiful red solution.

During the last few years so many new methods for obtaining hydrosols have been brought forward that they cannot be mentioned here. Some further important processes are, however, alluded to under the articles on GOLD and SILVER.

Although formerly only colloidal metals were investigated, chemists have now been able to obtain bodies, in themselves insoluble, in a soluble form or in extremely fine states of suspension. Indeed the whole matter is now considered in a wider sense. For instance silver chloride as well as silver bromide, and silver iodide have been obtained in solutions of gelatine, and colloidal indigo has been obtained by the aid of protalbinic and lysalbinic acids. See INDIGO DYES.

Carl Zeiss, Jena: Ultramicroscopy of Colloids, Mikro 229.

Colophony. This is obtained by heating turpentine or resin for some time without the addition of water, i. e. the oil or resin is distilled. Recently the distillation has been conducted in steam.

The resulting colophony is a yellow or brown resin which is brittle, transparent and almost odourless. S. G. 1.01 to 1.08. Soluble in alcohol, ether and oils. It softens at 70° and melts between 100° and 135° . By the dry distillation of colophony, resin oils, pinoline and combustible gases are obtained and at the same time acid liquors which are used in the manufacture of acetic acid. The residue is a kind of pitch.

In addition to the above-named uses, colophony is employed in the manufacture of varnishes, plasters, and cements.

Colorimetry. The colorimeter serves for comparing any coloured liquid A with another substance B (solid or liquid), with respect to the absorption of light by them. Two bottles close together, the so-called fields of comparison, are illuminated by A or by B. The depth of the layer of A — when B is a fluid, the depth of the layer of A or of B — is now changed, till the two fields of comparison are equally illuminated and appear of the same colour; when this is attained the measurements are made. The sensitiveness of the arrangement is greatly increased when the light that reaches the eye from the fields (comparison fields) is strongly absorbed by the substances to be compared. For this reason the light from the fields of comparison is either spectroscopically broken, or the experimenter looks through a suitable light filter, e. g. a coloured glass, into the comparison fields.

c_1 The required concentration (number of g in 100 ccm solution) of the solution of a coloured substance.

d_1 The depth of the layer of the solution.

c_2 The known concentration of a solution of the same substance.

d_2 The depth of the layer of this solution with similar light and colour of the comparison fields; then the required concentration is

$$c_1 = \frac{c_2 \cdot d_2}{d_1}$$

Colorimeters:

Hans Heele, Berlin O. 27.

Colours see the special articles.

Colours for China:

Johnson, Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Colour-Grinding Machines:

J. M. Lehmann, Dresden-A. 28, Germany (see front part advt.).

Combustol. A liquid antiseptic plaster containing salicylic acid in 4 % solution. It is used in skin diseases and for applying to suppurating wounds.

Compressed gases. Hydrogen, oxygen and chlorine are brought on to the market in this form of gas. Recently nitrogen has also been sold as a compressed gas. Ammonia, carbonic acid and sulphurous acids are not met with in a compressed state, but are sold as liquids.

Condensation of Gases

	Critical temperature	Critical pressure atm.	B. P. at atmospheric pressure	Melting point
Sulphur dioxide	+ 155°	79	— 8°	— 76°
Ammonia	+ 130°	115	— 36°	— 77°
Nitrous oxide	+ 35°	75	— 88°	— 115°
Carbon dioxide	+ 31°	73	— 79°	— 65°
Ethylene	+ 13°	52	— 102°	— 160°
Methane	— 82°	55	— 164°	— 185°
Nitric oxide	— 93°	71	— 154°	— 167°
Oxygen	— 118.8°	50.8	— 182.7°	—
Argon	— 121°	50.6	— 186.9°	— 189°
Carbon monoxide	— 140°	35	— 190°	— 207°
Air	— 140°	39	— 191°	—
Nitrogen	— 146°	35	— 194.4°	— 214°
Hydrogen	— 234.5°	20	— 243°	—

Compressing machines. Compression implies a pressing together of powder, grains, or leaf-like substances into a solid body, through pressure, without the addition of moisture.

The improved machines which have been introduced during the last few years, have rendered possible the preparation in this form of the most varied articles, in many branches of industry. Compressing machines have for the most part taken the place of lozenge cutters, thread cutters, casting moulds and hydraulic presses. The advantages of articles made by the compressing machine are on the one hand the accuracy in form and dose or weight of the objects, and the convenient packing thus made possible, together with the greater length of time the preparations keep; and on the other hand the fact that the cost of production is very low, the action being entirely automatic. The material is placed in the feeders in the form of dry powder. The machine is then adjusted for measuring off one, or it may be two, of the pressed cakes into the matrix holes. The stamp then falls pressing the substance into tablets, while the plate or rather counter-stamp which forms the bottom of the moulding holes rises, thus pushing up finished tablets which are automatically thrown out into receivers.

In choosing a compressing machine, care must be taken that the pressing agents lie in a space surrounded on all sides, as in the one-armed system

breaks often occur, and secondly that the matrices are adjustable, so that moulds of different sizes and shapes can be employed in the same machine.

The machines are employed for the following purposes among others.

1. In pharmaceutical chemistry for making compressed medicaments, such as rhubarb, soda, potassium chloride, quinine, aspirine, &c. Further saccharine and sugar tablets with medical additions, such as tolu, santonine, kermes, ipecacuanha, &c. can be obtained.

2. The salts of mineral waters are compressed together with suitable amounts of sugar. Among the mineral water salts in question may be mentioned those of Vichy, Carlsbad, Ems, Soden, &c.

3. In the branch of chemical technology are to be found compressed naphthalene in balls and tablets, ultra marine, incense and fumigating pastilles, disinfecting tablets, salt tablets, carbon briquettes, &c.

4. In the manufacture of cosmetics:— washing and bath ingredients, mouth washes, rouge, &c.

5. The wholesale chemical factories put out compressed soda blocks, salt in cakes, salamoniac in bars, and other articles.

6. Among confectioners' wares are:— compressed peppermint and fruit lozenges and tablets, cough lozenges and pastilles, effervescent lemonade, bonbons, and chocolate in cakes.

7. The food industry supplies soup tablets, tea tablets, coffee tablets, and many others all made with the compressing machines described above.

Compressers:

Emil Passburg, 30 Great Helens Street, London E.C.

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Condensation.

Condensation of gases:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Condensers:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Condenser Plants:

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Earthenware Condensing towers:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Earthenware Condensation Vessels:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Confectionery.

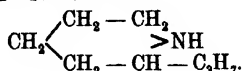
Confectionery, machinery, dyes:

Werner Pleiderer & Perkin Ltd., Peterborough.

Conephrine. A solution of cocaine and paranephine used as a local anæsthetic.

Coniine. An alkaloid of the hemlock, *Conium maculatum*, contained in all parts of the plant but especially in the fruits.

Coniine $C_8H_{17}N$, is α -propyl piperidine



The naturally occurring coniine is the dextro-rotatory form. It is prepared by allowing the crushed unripe seeds of the hemlock to swell in water and then moistening with concentrated Na_2CO_3 solution. The coniine is then removed by distillation with superheated steam. The distillate is treated with HCl , evaporated nearly to dryness, extracted with strong alcohol, and filtered off from the NH_4Cl . Finally the alcohol is distilled off, the product is accurately neutralised with NaOH and shaken out with ether; the solution is then strongly cooled, when other alkaloids separate and are filtered off, the ether being finally distilled off.

The coniine is purified by drying with K_2CO_3 and distillation in a current of hydrogen. Coniine has also been prepared synthetically. It is a colourless or very pale yellowish oily liquid with a most disagreeable smell. S. G. 0.850 to 0.860 at 15° . Its boiling point in a current of hydrogen is 167° , in air 165 — 170° . When strongly cooled it crystallises but melts again at -2.5° . It dissolves with difficulty in H_2O (more readily in cold water), but very readily in alcohol, ether, acetone, and oils.

It is a strong poison. It is used in medical practice externally in the form of ointment for alleviating pain. Inwardly it is given in cases of cramp of the stomach, whooping cough, neuralgia. It is sometimes administered subcutaneously.

Conserving. The treatment of perishable substances to increase their stability. Conservation is carried out by:

1. **COLD.** Ice safes, refrigerators, ice houses, transport ships with ice cooling apparatus, &c. are used for preserving foods, especially meat.

2. **DRYING.** As examples may be quoted codfish, meat powder, dried fruits, compressed and dried vegetables, &c.

3. **HEAT.** Killing the micro-organisms by heat is done by boiling the food substances, by disinfecting by steam, see **DISINFECTION**, and by **PASTEUR'S** method. This latter method is carried out by heating on several days each time to a temperature of 60 — 80° whereby the sterilisation is certainly complete but the nutritive substance is not so affected in taste and consistency as is the case by boiling.

4. **EXCLUSION OF AIR** while the microbes are being destroyed, or after this has been done. To this class of conserved articles belong tinned fruits, vegetables and other canned goods. While the contents are being cooked or immediately after, the tins are soldered in a water bath, as is the case also with the well known corned beef. Further we may mention sardines in oil; the covering of eggs with lime, the coating of fruit with melted paraffin, &c.

5. **BY THE USE OF CHEMICAL AGENTS.** To this class belong salting, and smoking in which not only drying, but also impregnating with antiseptic substances such as creosote and wood vinegar, pyroligneous acid, is essential. To this class belongs also treatment with strong sugar solutions for fruit, also with vinegar and solutions of salt and spirit. Other substances for preserving foods are usually forbidden, such as borax, boric acid, salicylic acid, and sodium bi-sulphite. Of late formaldehyde has been successfully used in very weak solution, or still more successfully in the form of vapour for the conservation of foods. For materials which are not intended for consumption, many other substances besides those named are used for conservation, such

as tannic acid for the conservation of animal skins, sulphuric acid for wine vats, numerous kinds of metallic salts for wood, and so on. Compare also the articles on **TANNING** and **WOOD**. For anatomical, zoological, botanical and other kinds of preserving, alcohol, glycerine, arsenic acid and mercuric chloride are used. Besides these, of late the preserving of the last named class of materials has been extensively done with a 0.2 to 4 per cent solution of formaldehyde.

Compare **MILK**, **DISINFECTION**, **MEAT PREPARATIONS**, and **ANTIQUITIES**.

Contact reactions. These are reactions which only occur in the presence of certain substances which themselves apparently suffer no change in the process. Such reactions are exemplified in **DEACON'S** process, in the preparation of formaldehyde and sulphuric anhydride. Compare also the article on **CATALYSIS**.

Germ. Pat. 142855 protects a contact apparatus for the preparation of SO_2 . This consists of woven materials stretched on frames, the former being platinised. Concerning the process involving the use of contact substances in which there is no loss of material see **CHLORINE**. (**DEACON'S** Process.— **Germ. Pat. 143828**.)

Cooling apparatus.

Cooling apparatus and worm-condensers:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 8b (see advts.).

Cooling Plants:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 8b (see advts.).

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Copaiva Balsam. Similar to the turpentine obtained from various species of pine. Prepared from certain trees (South America) belonging to the genus *Copaifera*.

It is a yellowish or pale brown liquid with a spice-like smell and a bitter, burning taste. When freshly-prepared it is oily but gradually changes into a resin. S. G. 0.935 to 0.998. Three kinds are recognised, viz. Brazilian, Para and West Indian.

Copaiva balsam is a valued drug. It is also used in the manufacture of varnishes and for rendering paper transparent.

Germ. Pat. 167170 protects a method for the manufacture of neutral preparations and **Germ. Pat. 183185** a method for the production of solid condensation-products of copaiva balsam.

Copal. This is the name applied to different resins of which the origin is only partly known. A distinction is drawn between hard and soft copals; important among the hard copals is the East-African or Zanzibar copal — probably a fossil gum — which is found in pieces as large as peas or the fist. Also the origin of the hard Sierra-Leone copals is unknown. Of the soft copals may be mentioned the West-Indian or ball copal, and especially the Kaurie copal. The former — which, it may be said, hardly ever reaches Europe — is derived from the tree *Hymenaea courbaril*, the latter from *Dammara australis* and *ovata*. The fresh gum of the Kaurie tree as well as the fossil resin found in the earth are now brought into commerce under the name Kaurie copal.

Zanzibar copal forms, after the removal of the impurities by scraping and washing, a colourless to brown-red glassy transparent mass the surface of which is like goose skin.

The ball copal forms a yellow or greenish-coloured mass usually coated with a crust of earth and possessing an unpleasant odour and bitter taste; it is found in ball-like lumps often as large as melons. Kaurie copal is very much harder than Manilla and ball copal although softer than the expensive Zanzibar copal. The Kaurie copal is, judging by the great demand, the most important kind of copal; it is found usually in pieces of the size of a nut or of the fist, more rarely in large lumps, which, however, sometimes occur weighing as much as 50 kg. The Kaurie copal has an oily lustre and possesses a pleasant taste and smell.

The above mentioned copals and the other occurring varieties may be distinguished by their specific gravities, which are most advantageously determined after removing the air by placing *in vacuo*.

	determined directly	determined <i>in vacuo</i>
Zanzibar copal	1.067	1.068
Angola copal	1.064	1.081
Brazil copal	1.018	1.082
Kaurie copal	1.050	1.115
Manilla copal	1.082	1.121

Hard copal melts at 340°, half hard at 180°. Copal is used for the preparation of the valued copal varnishes.

According to Dr. CARL GOLDSCHMIDT a substitute for copal may be artificially prepared from formaldehyde resin; a colourless resin, which is a good substitute for Indian and Zanzibar copal, may be obtained by allowing monomethylaniline to stand with HCl and excess of formaldehyde, precipitating the resin with sodium hydroxide, filtering, and allowing it to cool.

TEST. HERTKORN has worked out a method for determining the mineral and organic impurities in the hard resins (half hard and hard copals). The following extracts are taken from the Chemiker-Zeitung 1902, page 602. In this method a mixture of 20—25 parts of amyl acetate, 40—50 parts of amyl alcohol, and 25—40 parts of ethyl alcohol (above 96 % by wt.) is used as a solvent. The finely-pulverized hard resins dissolve in this mixture while the impurities remain behind undissolved. The method itself according to HERTKORN is as follows:— 5—10 grams of finely-powdered hard copal resin are exactly weighed, brought into a beaker (50—120 ccm) and treated with 25—50 ccm of the solvent described above. Care must be taken that the powder is constantly stirred with the solvent by means of a glass rod until there is no longer danger of lumps being formed. The beaker is then placed in water at 70—80° C., the mixture stirred until it starts to boil, and then digested for ½ to 1 hour. During this operation the beaker must be kept covered and the mixture stirred now and then.

After all the copal resin has gone into solution (this can be seen by the powdery sandy state of the undissolved parts as well as by the absence of resin on the glass rod), the mixture is allowed to settle and then the clear resinous solution carefully decanted (as long as it runs off clear) into a larger clean beaker. If by chance or carelessness the decanted liquid still contains sediment it must again be allowed to settle and then the sediment added to the bulk. The solvent described above may be used for washing and the sediment is then again treated as above with 25—50 ccm of the solvent. These manipulations are repeated until a drop of the decanted liquid, after being heated on a piece of platinum foil, shows the absence of resin. According to the nature of the impurities of the copal resin, filter paper — dried and weighed

at 105° — may be used for filtering the latter portions of liquid seeing that these solutions which contain less resin do not settle well and cannot be decanted free from sediment. Care must however be taken that the resin does not dry on the paper during these operations otherwise the pores become blocked and can only be incompletely opened by treating for a long time with solvent. The sediment free from resin and the filter paper are then washed twice with ethyl ether, the filter paper returned to the beaker, the ether allowed to evaporate, and then the whole dried at a temperature of 105° until the weight is constant. Different species of hard copal often contain fragments which resemble porcelain in appearance, give an intense and characteristic smell on being heated, are extremely hard, and can only with difficulty be brought into solution. At all events it is advisable to wash out with ether even in this case because the original solvent is removed and the residue can be more readily dried and weighed. If the sediment when dry adheres to the glass and is not perfectly powdery the treatment with amyl acetate or ether must be repeated. For the determination of the ash the sediment may be used or the original copal resin heated with ammonium nitrate in a platinum crucible. The method is specially suitable for splinter copal and dust copal. — The impurities of the latter vary between 0.5 % to 50 %, more than 5 % of organic impurities rarely occur, the average being 0.3—2.5 %, while from 1—5 % of mineral impurities may be found. Larger impurities consist of sand or earth. Further the copal always contains some of the raw fibres of the sacks.

Copal oils. For the preparation of oil-varnishes the copals are submitted to a dry distillation in which the escaping vapours were formerly allowed to escape; the distillate is now however usually preserved.

According to L. SCHMOELLING (Chem.-Ztg. 1905, 955) the copal oils are quite different products according to the material used. Thus the Kaurie oil derived from Kaurie copal forms a light mobile bright yellow liquid with a pleasant aromatic smell, S. G. at 15° 0.8677, which does not alter on standing in the air. On the other hand the Manilla oil, obtained by the distillation of Manilla copal, forms at first a rosy liquid which quickly turns cherry red. S. G. at 15° 0.9069. SCHMOELLING also obtained other interesting results but for these we must refer our readers to the original paper.

The copal oils are now only used to a small extent; they are partly burned and partly added in smaller amounts to varnishes.

Copper. Cu. At. Wt. = 63.3. The most important copper ores are copper pyrites $\text{Fe}_2\text{S}_3 \cdot \text{Cu}_2\text{S}$, purple copper ore $\text{Fe}_3\text{S}_4 \cdot 3\text{Cu}_2\text{S}$, copper glance Cu_2S , ruby ore Cu_2O , malachite $\text{CuCO}_3 + 3\text{Cu}(\text{OH})_2$, azurite $2\text{CuCO}_3 + \text{Cu}(\text{OH})_2$, as well as iron pyrites more or less rich in copper. The methods of obtaining copper may be divided into two classes — the dry and the wet methods; the dry method is more suitable for ores rich in copper, whereas the wet method may be more profitably employed where the ores are poor.

The dry smelting is carried out in hearth-, shaft- and reverberatory furnaces; the process with the oxide ores is very simple, but a very impure product is obtained. The winning of the copper from the sulphur ores is more complicated but allows of the direct production of purer copper.

The sulphur ores are usually roasted before smelting, but the roasting is only incompletely carried out, so that the roasted ore still contains copper and other sulphides. In this part of the process the oxidized iron forms with the silica which has been added a fusible slag which contains little or no copper. By repeating the roasting of this "coarse metal" an action takes place between the CuO (or Cu_2O) which is first formed and the Cu_2S still present with the formation of metallic Cu — the so-called "black copper"

containing 93—95 % Cu. The reaction is expressed by the equation $2\text{CuO} + \text{Cu}_2\text{S} = 4\text{Cu} + \text{SO}_2$. To avoid the different processes of roasting and smelting, the BESSEMER process (see "PIG IRON") has been recently used with advantage for the preparation of black copper from coarse metal. In the converter the "pyrites smelting process" also takes place; this can be used with all copper ores which contain Au, Ag, Cu and the necessary sulphur. To mixtures poor in sulphur, pyrites is sometimes added; besides this there must also be the necessary amount of silica present. It is advantageous to work with hot air.

The black copper is refined in order to remove the impurities and this is usually carried out by fusion with simultaneous oxidation. The impurities are partly carried away in the slag and partly volatilized. After this oxidation, which is accomplished by an air-blast, the metal is reduced by adding charcoal. The refining process is usually carried out in reverberatory furnaces.

The extraction of copper by the wet method is especially suitable for poor ores. In all these wet methods the copper must first be rendered soluble, then dissolved, and precipitated from the solutions, while the treatment of the "cement copper" forms the final process. The ores are converted into the soluble state by treatment with H_2SO_4 or with HCl or else they are submitted to a "sulphating" or "chlorinating" roasting (the latter with the addition of chlorides of the alkali metals) and afterwards lixiviated with water, dilute H_2SO_4 or salt-solutions. The copper is then usually precipitated from these lyes by means of iron, after which the resulting "cement" copper is submitted to different refining processes. Recently it has been proposed to pass SO_2 into a copper sulphate solution, cupro-cupri sulphite is thus precipitated and free H_2SO_4 formed; the latter decomposes the sulphite again into Cu and CuSO_4 . This process, proposed by VAN ARSDALE, is found in the English Pat. 2036 of 1903, while according to the Germ. Pat. 151658, SO_2 is allowed to act on copper oxide or copper carbonate which has been made into a paste.

The direct electrolytical process of winning copper has not yet come properly into use, although it is becoming of increasing practical importance. In the ordinary process the ores are lixiviated with ferrous sulphate (or with copper chloride). In these electrolytical processes the lixiviating salts — which become reduced to ferrous sulphate (or cuprous chloride) in the process of rendering the copper compounds soluble — are again oxidized at the anode when the solution is electrolysed, so that the method is continuous. The cathode is made of sheet copper and carbon rods form the anode. Numerous alterations and improvements cannot be discussed here. The Germ. Pat. 160046 which also treats of a direct electrolytical process may however be mentioned.

The electrolytical refining of copper is however of much greater importance than the electrolytical extraction of copper. In principle this process is the same as that of electro-deposition, that is, the electrolyte is an acidified CuSO_4 solution, the impure copper serves as anode, and pure copper is deposited on the cathode.

Finally it may also be mentioned that experiments have been made with a view of using the electric furnace in the smelting of copper ores.

Metallic copper is bright red with a high lustre, glistening, rather hard, and extremely ductile. S. G. 8.94. M. P. 1080° ; it "spits" on solidifying and is on this account difficult to cast. It may be welded at a bright red heat, but is brittle just below the M. P. and can then be readily powdered.

Because of its great conductivity it is largely used in electrical work. For this purpose it must be pure, since the presence of traces of impurities greatly lowers the conductivity. It is also used in the manufacture of various apparatus, in the construction of ships, for plates (engraving) &c.

The alloys of copper are most important (q. v.)

Copper tubes:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Copper adhesive meal. An effective remedy for *Peronospora viticola* in vineyards.

Copper alloys. Of the copper alloys the bronzes are treated in a separate article. ALUMINIUM BRONZE is described under "ALUMINIUM ALLOYS", "TUNGSTEN BRONZE" under "TUNGSTEN ALLOYS". Further "NEW SILVER" (ALFENIDES) under "NICKEL COMPOUNDS", "COPPER STEEL" under "IRON ALLOYS". "CUPROMANGANESE" under "MANGANESE ALLOYS".

1. **BRASS.** Copper-zinc alloy of very varying composition: Brass is a general name given to copper alloys with more than 18 % Zn. It is prepared by melting together the two metals in the requisite proportions.

2. **TOMBAC** (red brass). Copper-zinc alloys with less than 18 % Zn. Tombac with 12—18 % Zn is known under the name Talmi gold, Cuivre poli &c. Red and yellow brasses often contain Sn and Pb.

3. **DELTA METAL.** Copper-zinc alloys with 60 % Cu. These possess great strength and toughness on account of the presence of a small amount of iron: They can be welded at a red heat.

4. **GAUGING METAL** and **STERRO METAL** resemble delta metal and also contain iron.

5. **DURANA METAL.** An alloy of golden colour which consists principally of Cu and Zn; it can be welded. Durana metal is characterised by great strength and ductility. For rolled knives of a rag machine of durana metal the following results were obtained in the half-hard state: Limits of elasticity 35—40 kg, breaking weight 45—52 kg, expansion 12—18 %; in the hard state: Limits of elasticity 50—55 kg, breaking weight 60—65 kg, and expansion 8—12 %.

6. **PHOSPHOR COPPER.** Alloy of Cu with 5—15 % P. It is used as an addition to other metals and for refining purposes in order to obtain a dense casting free from bubbles. It is also used for the manufacture of phosphor bronze. See under BRONZE.

7. **SILICON COPPER** see SILICON.

8. **FALSE GOLD BRONZE** is powdered brass foil, see SHEET METALS.

Copper alloys:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Copper compounds.

1. **COPPER ACETATE** see VERDIGRIS under "COPPER COLOURS".

2. **COPPER CHLORIDES.**

a) **CUPROUS CHLORIDE** Cu_2Cl_2 . Obtained by boiling CuCl_2 with HCl and copper foil. White crystals insoluble in H_2O and alcohol, which oxidize in the air.

b) **CUPRIC CHLORIDE** CuCl_2 . Obtained by dissolving Cu in aqua regia or CuO or CuCO_3 in HCl. It forms light bluish-green crystals $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ which readily dissolve in H_2O and alcohol. On being heated the yellowish brown anhydrous salt is formed.

TEST. It is usual to test only for iron (by saturating the aqueous solution with NH_3) and to determine the amount of Cu in the hot hydrochloric acid solution, by means of stannous chloride solution according to WEYL's process. It is titrated until the green coloration completely disappears.

For further information see Zeitschr. f. analyt. Chemie, Vol. IX, Page 297.

3. **COPPER CARBONATE.** The normal salt CuCO_3 is unknown; the basic carbonate occurs in nature as mountain blue. A compound of the composition $\text{CuCO}_3 + \text{Cu(OH)}_2$ is artificially obtained by precipitating a lukewarm CuSO_4 solution (free from iron) with excess of Na_2CO_3 solution (or with CaCO_3), and washing and drying the precipitate. The colour is altered by the addition of heavy spar, gypsum or zinc white.

4. **COPPER CHROMATE** CuCrO_4 . It is obtained as a yellowish brown precipitate which contains H_2O by precipitating boiling CuSO_4 solutions with K_2CrO_4 ; in the anhydrous state it is black (chrome black). A solution of copper ammonium chromate is technically known as copper chromate. This solution which is used in dyeing is obtained by dissolving (at boiling point) 1 part $\text{K}_2\text{Cr}_2\text{O}_7$ in 20 parts H_2O and adding 2 parts CuSO_4 to this solution. The copper chromate is then precipitated by means of a concentrated Na_2CO_3 solution (1:2), decanted, the precipitate washed, dried until it forms a thin paste, and dissolved in as little ammonia (S. G. 0.91) as possible. The dark green solution is quickly filtered through flannel, concentrated to 25°Bé. , and stored in well-stoppered bottles.

5. **COPPER NITRATE** $\text{Cu(NO}_3)_2$. Obtained by dissolving Cu or CuO in HNO_3 . It forms blue crystals with varying amounts of H_2O . Basic nitrates are also known.

6. COPPER OXIDES.

a) **CUPROUS OXIDE** Cu_2O . Obtained by the incomplete oxidation of Cu (by heat), or by allowing Cu to stand in H_2O containing dissolved air. Also by boiling an alkaline solution of equal parts of CuSO_4 and grape-sugar; it forms bright red crystals or powder. Glasses are coloured red with Cu_2O .

b) **CUPRIC OXIDE** CuO . Obtained by heating $\text{Cu(NO}_3)_2$ or igniting Cu in the air. Black amorphous mass which is readily reduced to Cu at a moderate heat by organic substances. Its use in elementary analysis depends on this fact. CuO colours glass green.

c) **COPPER HYDROXIDE** Cu(OH)_2 . Obtained by the action of KOH or NaOH on solutions of cupric salts as a bluish green bulky precipitate. It dissolves in NH_3 to a solution of a dark blue colour which dissolves cellulose. It dissolves in NaOH and KOH only in the presence of organic bodies such as tartaric acid, sugar, &c. On being heated (even under H_2O) the hydroxide is converted into CuO . The intermediate stages are blue or dark blue in colour.

7. **COPPER SULPHOCYANIDE** $\text{Cu}_2(\text{CNS})_2$. Obtained as an insoluble precipitate by treating crude sulphocyanide liquors with CuSO_4 and SO_2 . Iron vitriol may also be used as a reducing agent instead of sulphurous acid.

It is sold commercially in the form of a paste (white paste).

8. **COPPER SULPHATE.** (Copper vitriol, blue vitriol) CuSO_4 . Obtained by treating copper waste, copper turnings, malachite, or black copper with H_2SO_4 , also by heating Cu with S, roasting the resulting copper sulphide and lixiviating the product.

According to a paper read by GIN (of Paris) at the International Congress for Applied Chemistry held in Berlin 1903, CuSO_4 may be made by submitting iron and copper ores to a "sulphating" roasting, then lixiviating with H_2O , converting the ferric salts by means of SO_2 into ferrous salts, and heating in autoclaves to 180° . At this temperature the CuSO_4 is said to be still soluble, the FeSO_4 on the other hand insoluble, so that the solution can be separated from iron by pressing. The most suitable strength of the solution is said to be 350—400 g sulphate per 1 litre.

According to Germ. Pat. 120822 and 135182 for the preparation of metallic sulphates from the sulphides, the latter (in this case copper sulphide) are heated in the absence of air and in the presence of iron bisulphide with alkalimono- or poly-sulphides, then allowed to decompose in the air, and finally left to oxidize (it is an advantage to heat the mass gently during

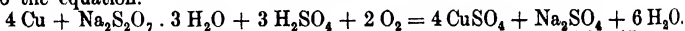
this process). The resulting CuSO_4 can then be lixiviated while the Fe_2O_3 remains behind. Half-smelted ores which still contain sulphur compounds give better results when subjected to this treatment.

According to the Germ. Pat. 144992 the copper ore is roasted until the sulphide is converted into oxide and then converted into sulphate during cooling. Besides the CuSO_4 basic iron sulphate is also formed; the latter does not pass into solution and can be used for treating a further quantity of ore.

According to the Germ. Pat. 127423, CuSO_4 may be prepared electrolytically by decomposing an alkali sulphate solution using a copper anode. Between the anode and the cathode chambers are two porous walls about 1 cm apart through which a liquid (sulphuric acid or a solution of acid-sulphates of the alkali metals) flows so as to remove immediately the products of reaction. In this way the porous walls cannot be blocked by the precipitation of CuO .

The Germ. Pat. 156354 also gives a method for manufacturing CuSO_4 electrolytically by making use of a copper anode and a diaphragm. The electrolyte, however, consists of an alkali chloride solution in which a small amount of copper chloride is dissolved. In this way caustic alkali and copper chloride are obtained; the latter is then converted by means of conc. H_2SO_4 into the sulphate.

According to the Germ. Pat. 157107 waste products containing metallic Cu are treated in such a way that they are caused to react with sodium bisulphate and concentrated H_2SO_4 in approximately molecular proportions (2 : 3), at a temperature of 100° – 110° in the presence of an oxidizing agent (e. g. hot air). The above mentioned proportion is chosen according to the formation of the so-called pentasulphate. CuSO_4 is then obtained according to the equation.



Copper sulphate crystallizes with 5 H_2O in blue columns which effloresce superficially in the air, become white at 200° . At this temperature all the water is driven off. This calcined copper vitriol on account of its hygroscopic qualities is used for removing the water from alcohol. Copper vitriol is poisonous and has a metallic taste. 100 parts H_2O dissolve at 10° 37 parts, at 40° 57 parts, and at 100° 203 parts of vitriol. Copper vitriol is insoluble in alcohol.

It is used in dyeing and in calico printing, in electro-deposition, for the manufacture of copper colours and other copper compounds, for preserving wood and animal skins, in agriculture for destroying parasites, in medicine, &c., &c.

9. COPPER SULPHIDES.

a) CUPROUS SULPHIDE Cu_2S . Is formed by heating Cu in sulphur vapour.

b) CUPRIC SULPHIDE CuS . Obtained by precipitating copper salts with H_2S or ammonium sulphide. Black amorphous precipitate.

10. COPPER VITRIOL see 8. COPPER SULPHATE.

11. COPPER WATER = Iron sulphate, see under IRON COMPOUNDS.

Copper colours.

1. BREMEN BLUE (Bremen green); according to composition it is $\text{Cu}(\text{OH})_2$, a bluish-green not very stable colour, which is obtained by precipitating a concentrated CuSO_4 solution with a small amount of KOH, and treating the filtered doughy precipitate with dilute KOH.

2. CASSELMANN'S GREEN (basic copper sulphate) $\text{CuSO}_4 \cdot \text{Cu}(\text{OH})_2 + 4 \text{H}_2\text{O}$. Obtained by mixing an aqueous solution of 4 parts of CuSO_4 with a solution of 3 parts of $\text{Na}_2\text{C}_2\text{H}_3\text{O}_2$ at boiling point. It forms a very beautiful green copper paint, the "fire" of which may be increased by careful washing with sodium hydroxide.

3. **CHALK BLUE** (Neuwieder blue). Mixture of $\text{Cu}(\text{OH})_2$ with CaSO_4 , obtained by adding milk of lime to a mixed solution of CuSO_4 and NH_4Cl , washing with water, grinding and drying the resulting precipitate.

4. **GENTELES GREEN** (tin green), copper stannate. It is prepared by converting 59 pts. Sn into SnCl_4 by means of aqua regia, adding a solution of 125 pts. of CuSO_4 , and precipitating the colour with NaOH .

5. **MINERAL BLUE**. Artificial copper azure (see above). Obtained by precipitating $\text{Cu}(\text{NO}_3)_2$ solution with KOH or NaOH ; the colour may be shaded by mixing with white mineral paints.

6. **MOUNTAIN BLUE** (azure blue, mineral blue, copper blue, Hamburg blue, English blue), basic copper carbonate $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$. Poisonous mineral which on account of this property and its small "body" is now seldom used as a paint.

7. **MOUNTAIN GREEN**. Partly the natural mineral malachite closely related to mountain blue $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$, and partly artificially obtained by precipitating a CuSO_4 solution with a Na_2CO_3 or CaCO_3 . The latter is called **BRUNSWICK GREEN**.

8. **OIL BLUE** CuS . Obtained by plunging Cu into boiling S, or by melting together potassium sulphide and Cu; the melt is in the first case digested with NaOH , in the second with H_2O , and then extracted. It is a violet colour which is only stable when varnished.

8. **VERDIGRIS** (copper acetate); a distinction is made between normal copper acetate $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{H}_2\text{O}$ and basic copper acetate $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{Cu}(\text{OH})_2 + 5\text{H}_2\text{O}$. The basic or blue verdigris is obtained from wine residues after the sugar has been fermented to acetic acid. The husks are laid on warmed copper plates, warmed and the verdigris scraped off with copper knives after it has attained a sufficient thickness. A greener basic verdigris may be obtained by treating copper plates with flannel rags soaked in vinegar.

Neutral verdigris is usually obtained by treating the basic salt with acetic acid; it may also be obtained directly from CuSO_4 by decomposition with sugar of lead.

Basic copper acetate forms bluish-green scaly crystals, or a light blue powder which is decomposed by H_2O so that it cannot be used as a water colour. Neutral verdigris forms dark blue-green crystals which gradually effloresce in the air and are readily soluble in water. Verdigris is now but seldom used as an independent colour, and is principally employed in the manufacture of Schweinfurter green.

9. **SCHÉELE'S GREEN** (mineral green, Swedish green, copper arsenite) CuHAsO_3 . Formerly obtained by boiling As_2O_3 with potash solution and treating the resulting potassium arsenite solution with a hot CuSO_4 solution, but now produced electrolytically by allowing the current to act on a hot solution of Na_2SO_4 in which copper plates and small bags containing As_2O_3 are suspended. Na_2O_2 is formed at the cathode and this dissolves the As_2O_3 , while the CuSO_4 formed at the cathode combines with the sodium arsenite to form a precipitate of SCHÉELE'S green. On account of its being so extremely poisonous and its possessing so little "body" this otherwise very beautiful colour is now little used.

10. **SCHWEINFURTER GREEN** (Kaiser green, meadow green, English green, patent green, parrot green, &c., &c.). Copper acetate arsenate $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{CuAs}_2\text{O}_7$. Obtained by mixing copper acetate and As_2O_3 in equivalent amounts at boiling point, or by dissolving lime and CuSO_4 in vinegar and adding a boiling solution of As_2O_3 . It is also obtained electrolytically in a manner similar to SCHÉELE'S green. This — the most beautiful of all green colours — is brought into commerce partly pure and partly combined with heavy spar; it is exceedingly poisonous. AsH_3 is evolved by the action of the air.

The other copper paints are of only little importance.

Copper mordants. Certain copper compounds such, as copper acetate, copper chloride, copper nitrate, copper sulphate, and copper sulphide, are, comparatively speaking, but little used as mordants or oxidizing agents in dyeing and textile printing.

Copper sulphide is used in aniline black printing as well as in wool dyeing with logwood. In cotton dyeing with logwood and catechu copper sulphate is employed for increasing the fastness, and also in silk dyeing with the same dyes for the production of a blue black. Various substantive dyes are rendered faster by treating the dyed cotton fibres with copper salts.

Copper plating. This is always done by electrolysis, the baths used being acid, neutral, or alkaline. Alkaline baths are used for copper plating zinc, tin, and iron, as these three metals are attacked by H_2SO_4 .

For general details of this process, see the article on **ELECTROPLATING**. The acid copper baths are essentially the same as those used in **ELECTRO-DEPOSITION** (q. v.). The alkaline copper baths are solutions of the double salt potassium copper cyanide.

ALKALINE COPPER BATH (LANGBEIN) 200 g of neutral copper acetate are dissolved in 5 litres of H_2O , 250 g of crystallised sodium carbonate, and 200 g of dry sodium bisulphite and a solution of 225 g of the purest potassium cyanide in 3 litres of H_2O , is added to the neutral copper acetate, and the mixture diluted to 10 litres. The solution must be colourless or pale yellow. If dark in colour a little more potassium cyanide must be added. Current necessary: 0.5 amp. for 1 sq. m at 3—3.5 volt.

COPPER BATH WITHOUT POTASSIUM CYANIDE. 350 g of copper sulphate in 5 litres of H_2O are added to a solution of 1600 g of potassium sodium tartrate (ROCHELLE salt) and 800 g of caustic soda in 5 litres of water. Another bath (ROSELEUR), which has proved very useful for zinc objects is as follows. 10 litres of H_2O , 190 g of sulphate of copper, 190 g of cream of tartar (free from lime), 425 g of crystallised sodium carbonate and $\frac{3}{4}$ of a litre of sodium hydroxide solution of $16^\circ B\acute{e}$.

Plates of quite pure electrolytic copper are used as anodes. The copper plated articles are taken from the bath, burnished with copper wire brushes, then rinsed several times in cold water, then in hot H_2O , after which they are rubbed dry with saw dust, dried quickly in an air bath and finally polished if a high lustre is desired.

Copper Plating:

Cannings, Gt. Hampton St., Birmingham.

Sheet copper:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Cornite see HORN, ARTIFICIAL.

Corks. According to Germ. Pat. 161987 pieces of cork are boiled in a mixture of 4 parts of linseed oil and 1 part of colophony until loosened. The residual resin is burnt away and the ash removed. The cork is said to increase considerably in volume and also to withstand longer immersion in water without becoming saturated. The method is valuable for the manufacture of life belts. According to Germ. Pat. 162836 corks are treated with some disinfectant gas such as formaldehyde, heated (dry heat) to 80° to 100° in order to complete the sterilization and to remove the excess of gas. See **CORK SUBSTITUTES** and **SUBERITE**.

Cork Crushers:

Max Friedrich & Co., Leipzig-Plagwitz 17.

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Corkstone. This substance is made by a patented process from finely-divided cork and a mineral cementing material. It is largely used, on account of its non-conducting and fireproof properties, in building construction. By impregnating corkstone *in vacuo* with molten pitch under pressure a modification of the ordinary corkstone is obtained which is proof against both fire and water. This substance has a S. G. 0.30 to 0.40 and is the lightest material used in building.

Cork substitutes. These are prepared by many different methods. See SUBERITE.

According to Germ. Pat. 167780 by the action of acetylene on copper at a temperature of 200° to 250° under constant pressure a brown homogeneous, elastic product, *cuprene*, is obtained which is exceedingly light and forms an excellent substitute for cork. It may be worked into any desired form, can be cut with a knife, does not absorb water and has only half the density of cork.

According to French Pat. 370637 caseine is thoroughly mixed with slaked lime, boric acid and cork residues, forced into metal moulds under hydraulic pressure and heated to 120° . A cork substitute is thus obtained. (The method seems open to question.)

According to Germ. Pat. 185714 fine cork waste is mixed with egg-albumen solution and the mixture pressed into moulds and heated in steam.

Cork carpets see LINOLEUM.

Corubine. A registered (German) name for artificial corundum. It is obtained as a slag in the aluminothermy process and is used in the manufacture of fire-proof stones.

Corundum, artificial. The Norton Emery Wheel Company manufacture artificial corundum by fusing natural bauxite in electric furnaces and then allowing the melt to cool gradually. The product is as hard as natural corundum and as tough as emery, and therefore well adapted for making emery paper and emery stones.

Again artificial corundum is made by the so-called process of aluminothermy. See THERMITE. The corundum is obtained by heating a mixture of powdered Al with metallic oxides whereon the latter are reduced to the metal in question while the Al is oxidized to Al_2O_3 in the form of corundum. The Germ. Pat. 158336 protects a process for the manufacture of chemical apparatus from corundum and a clay cement; after being moulded the articles are fired and if necessary, glazed. The Germ. Pat. 160780 protects for the same purpose the employment of the corundum obtained as a slag in the process of aluminothermy.

FREMY was the first to succeed in producing the precious corundums (rubies and sapphires) by fusing amorphous Al_2O_3 with PbO in a Hessian crucible at a red heat.

The silica of the crucible reduces the lead aluminate first formed and the alumina separates in beautiful crystals. If a little chromium oxide be added the crystals formed are similar to those of the natural red ruby, while an addition of a little cobalt oxide would produce the blue sapphire. The process of producing artificial rubies has of late been considerably improved by VERNEUL, *Compt. rend.* 135791. He places a small rod of clay into the point of an oxy-hydrogen flame which points downwards. A finely powdered mixture of chromic oxide and alumina is sprinkled in the path of the gas mixture. These particles melt in the flame to tiny drops which settle on the point of the clay in the form of pyramids. At the apex of the pyramid the clay rod gra-

dually fuses, the pyramid is drawn out of the flame, becomes larger in the process and owing to the vibration breaks off. After this the ruby only needs to be cut and polished.

Cotargite. Under this name is sold a double salt of ferric chloride and cotarnine hydrochloride.

Cotarnine. $C_{12}H_{13}NO_3 + H_2O$. A decomposition product of narcotine (see OPIUM and OPIUM ALKALOIDS). It is obtained by the oxidation of narcotine with dilute HNO_3 .

The hydrochloride is used medicinally under the name of stypticine q. v. The compound with phthalic acid is similarly used under the name of styptol q. v.

Cotton. The seed filaments of various species of *Gossypium*. When ripe the fruit capsule bursts and the hairs protrude. The seeds are separated by the ginning machine and the cotton is pressed into bales and so brought into the market. Different kinds are recognised according to the origin, viz. North American, South American, East Indian, West Indian, Egyptian, Levant an European. The length of the fibre is sometimes as much as 40 mm. When the length exceeds 25 mm the cotton is called long stapled, when less than 25 it is called short stapled. The diameter of the fibre varies from 0.010 to 0.035 mm.

The most important chemical process to be noted in the manufacture of cotton is that of mercerization. This has for its object the imparting to the cotton a silky lustre, a result attained by different methods.

1. The cotton is soaked in a solution of caustic soda, squeezed to get rid of excess of liquor, stretched to the original length, or even a little beyond this, and finally washed while still in a state of tension.

2. The cotton is first stretched on frames and then mercerized with caustic soda. In this manner the cotton is prevented from shrinking. In order to increase the lustre, the fibres are stretched in this method too, a little beyond the original length. The process of mercerization not only increases the lustre but also the strength and the ease with which the cotton may be dyed.

Test. In order to distinguish between mercerised and unmercerised cotton the following test is recommended by LANGE (apart from microscopic tests), Report to the International Congress for Applied Chemistry, Berlin 1903.

A cold saturated solution of zinc chloride is mixed with a solution of potassium iodide and saturated with iodine e. g. 30 g $ZnCl_2$, 5 g KI and 1 g I are dissolved in 24 cc of water, or 5 g of KI are dissolved in 12–24 g of water, 1–2 g of I are added and the solution mixed with one containing 30 g $ZnCl_2$ in 12 cc of water. Such solutions give a blue colour to non-mercerised cotton, which disappears entirely when the cotton is rinsed in cold water. In the case of mercerised cotton the colour persists. The test may be carried out by taking two samples of the material, moistening the one with water and sprinkling both with the $ZnCl_2$ solution. A comparison of the two samples shows at once whether the cotton has been mercerised, or not.

If the colour of the material obscures the test the material may first be bleached with bleaching powder or some other substance before carrying out the test.

Cotton dyeing. Cotton is usually dyed in the form of yarn or when woven, and only rarely in the state of fibre. When pale colours are to be dyed the fibres are generally bleached before spinning. Otherwise the goods are boiled in a weak solution of caustic soda and soap to remove traces of oil, &c. The fibres must be thoroughly saturated before mordanting and dyeing.

The affinity of cotton fibres for most dyes is so small that it is necessary first to mordant the fibres so that the dye may be fixed. Recently dyestuffs have been discovered which dye cotton directly, i. e. without the addition of a mordant. See ALUMINIUM MORDANTS, CHROMIUM MORDANTS, COPPER MORDANTS, IRON MORDANTS, OIL MORDANTS, SUBSTANTIVE DYES, SULPHUR DYES, TANNIN MORDANTS, TIN MORDANTS, TURKEY-RED DYEING and BASIC DYESTUFFS.

Cotton dyeing with the aid of mordants is spoken of as adjective cotton dyeing. Almost invariably the mordant is first applied in a separate bath, the most usual for basic colours being tannic acid. Before the colour is applied the mordant is fixed often by treatment with tin or antimony salts. For other coal-tar dyes and particularly for vegetable dyestuffs aluminium mordants are used. When no mordant is employed the process is called substantive dyeing. In this, the dye-bath is made up with the addition of Marseilles soap with the addition of NaCl or Na_2HPO_4 , the dyeing is begun at about 40° and the temperature gradually raised to boiling.

To give to cotton the properties of the animal fibres, it is impregnated with a solution of glue or gelatine.

Cottonseed oil. An oil prepared from the seeds of *Gossypium herbaceum* (chiefly in America). The seeds are separated from the fibres in ginning machines so that the former are torn and crushed by rotating knives. The seeds so divided are then pressed out into cakes between iron rollers, the cakes are placed in sacks and squeezed in hydraulic presses. The whole is at the same time heated and the oil thus pressed out hot. It is also obtained by cold pressing i. e. by extraction with petroleum ether, benzine, &c.

Crude cottonseed oil is thick, dark-brown and muddy. In order to purify it it is mixed with a certain amount of caustic soda solution (15°Bé.), the quantity necessary being determined by previously testing. A solution of salt may be added in order to facilitate the separation. This method is best carried out by allowing the alkali to flow into the oil in thin streams and constantly stirring the whole. This latter object is attained by means of a current of air. When the oil "breaks" the temperature is raised (not above 60°), the operation being at an end when the separated liquor turns black. It is then allowed to settle, the clear oil washed with water and filtered through a filter press. If the oil be very acid it is first neutralised with Na_2CO_3 and the soap so formed skimmed off. The latter is used for the preparation of oleic acid.

In other methods of purification water glass, milk of lime, $\text{K}_2\text{Cr}_2\text{O}_7$, bleaching powder, &c. are employed and the process is as a rule repeated.

Refined cottonseed oil is pale yellow, and the colour cannot be removed by bleaching powder. S. G. at 15° 0.920 to 0.922. At 0° it has the consistency of butter. Saponification number 195 to 198; M. P. of the fatty acid 27.7 . Iodine number 105 to 115. It is to a slight extent a drying oil, but is used principally for the preparation of soap. The refined oil is also used for the adulteration of olive oil, lard, &c.

Coumarine. The aromatic principle of many plants, occurring mainly in the Tonka bean and in hay, woodruff &c. In other plants it is formed on drying as in hay. It is prepared by extraction of the Tonka bean with alcohol and forms rhombic crystals with an aromatic spicy odour like that of woodruff. M. P. 67 , B. P. 205 . Soluble readily in alcohol but with difficulty in water. It is the anhydride of coumaric acid and may be prepared synthetically by heating 3 parts of salicylic aldehyde with 5 parts of acetic anhydride and 4 parts of anhydrous sodium acetate under a reflux condenser. Coumarine is employed in perfumery for the preparation of the scent known as New-Mown Hay.

Coxine. This is the name applied by LUDWIG to a red solution of coal-tar dyes which absorbs the actinic rays. According to Germ. Pat. 136061 in order to develop photographic plates in daylight they may be immersed in a bath of this solution, the film is coloured red uniformly and is then quite insensitive to light. After the development is complete and the plate is fixed the colouring matter is removed by thorough washing in cold water.

The hopes raised by the introduction of this substance seem not to have been justified.

Cranes.

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Cream of Tartar. Potassium bitartrate $\text{K}_2\text{H}_2\text{O}_4$. This substance is found widely distributed in the vegetable kingdom and separates as a crust in wine vats, &c. The argol (i. e. cream of tartar) from white wine is grey, while that from red wine is red. Purification is carried out by grinding, dissolving in boiling water, adding HCl, allowing to settle and then evaporating the clear solution. From the crystals of semi-refined tartar, after dissolving it in H_2O , decolourizing with animal charcoal, clarifying with clay, filtering, reducing and recrystallizing, the pure tartar (cream of tartar) is obtained. It forms small colourless crystals with an acid taste, which dissolve in 180 parts of cold or in 15 parts of hot water. The crystals are insoluble in alcohol. On heating it with KNO_3 a black or white flux is obtained. This is really K_2CO_3 , the white form free from C, whilst the latter contains O. The method of the English Pat. 11991 of 1904 is mentioned in the article on TARTARIC ACID. For the manufacture of pure cream of tartar the dry material must be dissolved in boiling water without the addition of HCl. When necessary, the preparation is decolourized with animal charcoal, the cream of tartar crystallized out and again recrystallized from boiling water.

According to Germ. Pat. 177173 the crude argol is boiled with a solution of oxalic acid. In this way Ca oxalate is formed and tartaric acid set free. Potassium bitartrate can then be precipitated by the addition of KCl.

Cream of tartar is used as a mordant, further for the preparation of tartaric acid and tartrates, for cleaning silver articles which have become yellow, for wet silver-plating, for tin-plating, for the manufacture of baking powder, and in medicine.

Test. Cream of tartar usually contains varying amounts of calcium tartrate and is sold either in the form of crystals, or as a fine powder. Its purity is tested as described under TARTARIC ACID. When cream of tartar is ignited and the residue is extracted with HCl, the sample should give no precipitate with ammonia on boiling. The amount of tartaric acid can be determined by titration; the Ca in the usual way by gravimetric analysis.

Cremnite. A new building material made from clay, sand and fluor-spar. The materials are finely ground and mixed together and then fused at a high temperature. The fused mass may then be cast into any desired form. Cremnite is not attacked by fire or atmospheric agencies (e. g. frost), does not oxidize nor effloresce. It may be coloured or glazed in any desired way.

Creoline. A disinfectant which is insoluble in water. With water however it forms a permanent emulsion. Such emulsions are prepared from creosote oil, q. v., and contain 25 to 30% or more of the oil. Resin soap is added in order to produce the emulsion.

The name creoline is now registered in Germany as a description for pharmaceutical preparations, for disinfectants and materials for the preservation of wood, &c.

Creosol soap. An antiseptic used in midwifery. It is a potash soap soluble to any extent in water, containing 50 % of crude cresols.

Creosotal. A carbonate of creosote, prepared according to Germ. Pat. 58129 by passing COCl_2 into a solution of creosote in NaOH , washing the oil which separates first with a solution of Na_2CO_3 and then with water. It is an amber-coloured oil of the consistency of honey, soluble in alcohol but not in water. It has the odour and taste of creosote and is used medicinally as an internal antiseptic in cases of tuberculosis, lung disease, stomach and intestinal complaints. It has an advantage over creosote in that it is not so unpleasant to take, is more readily absorbed and has no irritating action.

Creosote. A colourless oily liquid with a decided smoky smell prepared from wood-tar, more particularly from beech-wood tar, by fractional distillation. For its preparation the fraction of the distillate heavier than water is used. This is washed with a solution of Na_2CO_3 , redistilled to remove the lighter fractions the heavier portion again washed with KOH and the alkaline solution treated with H_2SO_4 . These processes are repeated until the product dissolves in KOH to a clear solution. It is then redistilled and the portion coming over between 205° and 220° collected.

On keeping, particularly in the light, creosote gradually becomes yellow or brownish. It is readily soluble in alcohol and ether. 1 part dissolves in 120 parts of hot water, but it is soluble only with difficulty in cold water.

The most important constituent of creosote is guaiacol, q. v.

A distinction must be drawn between the product obtained from beech-wood tar and that prepared from coal-tar. The latter consists mainly of phenols and is particularly rich in creosols.

Creosote oil. The fraction passing over in the distillation of coal-tar between 250° and 280° . It is an oily, yellowish-green, strongly fluorescent liquid with a most unpleasant smell. S. G. 1.05. It is chiefly used in the crude state as an illuminant, for fuel, for the preparation of lampblack, for preserving timber and for the preparation of creolin, q. v., lysol, q. v., and other disinfectants. A similar substance is also prepared from the brown-coal-tar.

Creosote Oil:

Brotherton & Co. Ltd., City Chambers, Leeds.

Creosote pitch.

Forbes, Abbott & Lennard Ltd., 85 Gracechurch St., London E.C.

Cresols. Methyl phenols. $\text{C}_6\text{H}_4(\text{OH}) \cdot \text{CH}_3$. These are homologous with the phenols, but have a stronger disinfecting power than these, hence the superiority of crude over purified carbolic acid. By treating the cresol with caustic soda a preparation, soluble in water, (the sodium compound), is obtained which is of importance as a disinfectant. **SOLUTOL** is obtained in this way, while for rendering lysol soluble, soap is employed and for **SOLVROL**, the sodium salt of cresotinic acid. The crude cresol contains three isomers. From it pure cresol can be separated by freezing. Another patented process for the isolation of o-, m-, and p-cresol from the mixture of coal tar cresols, is based on the different solubility of the m- and p-cresol sulphonic acids in concentrated H_2SO_4 . The o-cresol is separated by fractional distillation. Special attention has been aroused by a new process which effects the separation of p- and m-cresol by the use of oxalic acid. According to this method Germ. Pat. 137584 and 141421 the commercial cresol, which contains p- and m-cresol after the separation of the orthoderivates by freezing, is heated with anhydrous oxalic acid or an anhydrous acid oxalate. This produces p-cresol ester of oxalic acid, which is removed from the solution by crystallization, while the m-cresol

which is not esterified remains dissolved. The ester is a colourless solid substance which is soluble in alcohol, ether and glacial acetic acid, but insoluble in benzene. It can be purified by sublimation and decomposed by water.

According to Germ. Pat. 148703, m- and p-cresol are separated by obtaining the former in the form of a sulphonic acid, by treating the crude cresol with sodium bisulphate containing pyrosulphate at a temperature of 100–110° and separating the sulphonic acids obtained, or their Na salts, from the unchanged p-cresol.

The Germ. Pat. 152652 for the separation of m-cresol from crude cresols is based on the fact that the neutral Ca salt of m-cresol is much less soluble than the corresponding salt of p-cresol. Cresol is saturated with Ca(OH)_2 till the neutral salts are formed; is then allowed to crystallize and the crystals which are rich in calcium m-cresolate are separated from the mother liquor which contains a large proportion of the calcium salt of p-cresol. The process is repeated. The crude cresol may also be treated with less Ca(OH)_2 and the neutral Ca salt which separates pressed to free it from the mother liquor, or washed out with benzene or some other substance.

o-CRESOL forms colourless crystals, sparingly soluble in water, readily in alcohol and ether. M. P. 31°; B. P. 188°.

m-CRESOL is a liquid which solidifies with difficulty. M. P. 4°; B. P. 201°.

p-CRESOL forms colourless prisms M. P. 36°. B. P. 198°.

Crurine. This is quinoline bismuth thiocyanate $(\text{C}_8\text{H}_7\text{N} \cdot \text{HSCN})_2\text{Bi(SCN)}_3$. It forms a fine crystalline powder of the colour of sealing wax, insoluble in absolute alcohol and ether, soluble in acetone and to a slight extent in pure glycerine. It is partially decomposed by water.

It is prescribed for external use in case of syphilitic lesions in the form of a starch powder. It is also recommended in the form of a 0.5 % aqueous-glycerine injection for gonorrhoea.

Crushing Machinery.

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Cryolite. A mineral having the composition $\text{AlF}_3 \cdot 3 \text{NaF}$. It is used mainly for the preparation of metallic aluminium q. v. and also in the manufacture of sodium carbonate, alum and aluminium hydroxide. It is also employed for rendering glass opaque.

Cryptolite:

Humann & Teisler, Dohna Bez. Dresden, Germany.
Willy Manger, Dresden, Germany.

Cryptol. While all other electric heating contrivances are based upon the use of metallic resistances in the form of wire or foil, the cryptol appliances are made of "cryptol", a mixture of carbon, graphite and carborundum, &c. according to the patent of Dr. VOELKER. The exact composition of the cryptol, which varies according to the use to which it is to be applied and to the strength of the current, is preserved as a secret by the Cryptol Company. The whole method and most of the apparatus used are fully protected by German and foreign patents.

It is usually employed in the following way. The granular substance is placed loose on a plate of fire-clay or some other insulating material and placed in connection with the current by means of carbon electrodes. This arrangement has considerable advantages over others in that the resistance can be readily altered when difficulties arise owing to impurities, &c. Further the temperature may be regulated by increasing or decreasing the thickness of the cryptol layer in any particular place, and the cryptol adapts itself

to vessels of any shape. A still greater advantage is this. Temperatures unattainable by the use of metallic resistances can be obtained by its use. Were it not for the limits imposed by the resistance of the fire-clay or insulating material used temperatures of 3000° could be easily obtained, and, as it is, 2000° to 2200° are the temperatures attained and this marks a considerable advance in heating. The temperatures in VÖELKER'S method can be regulated by altering the thickness of the layer, by using cryptol of different degrees of coarseness, and by including in the circuit metallic resistances of the ordinary type.

The development of the cryptol method necessitated the perfection of laboratory apparatus and now a great variety of these is on the market, e. g. combustion furnaces, boiling apparatus for KJELDAHL'S method and for gold assaying, drying ovens, muffles, waterbaths, heating plates, &c.

Crystallisation.

Crystallizing Vessels of Earthenware:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Cumene. Isopropylbenzene $C_6H_5CH(CH_3)_2$. Prepared by various methods e. g. by the action of zinc methyl on benzylidene chloride. A liquid B. P. 152, S. G. 0.87976 (at 0°).

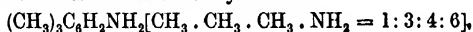
Pseudo cumene (as-trimethyl benzene $C_6H_3(CH_3)_3$ 1:3:4).

Found in coal-tar and obtained from it by first forming the sulphonic acid. Liquid B. P. 169.8, S. G. 0.8643 (at 0°).

Cumidine. Amidoisopropyl benzene $H_2N.C_6H_4.CH(CH_3)_2$. Obtained by the reduction of nitrocumene, which latter may be prepared in the usual manner by the nitration of cumene.

Liquid B. P. 225, S. G. 0.9526.

Pseudocumidine Amido-as-trimethylbenzene



Obtained by the reduction with Sn and HCl of nitropseudocumene. It forms crystalline needles M. P. 62. On a large scale it is prepared from m-xylidine by heating with methyl alcohol and HCl to about 290° . The bases separated from the hydrochlorides so obtained are separated by fractional distillation.

The above-mentioned compounds are used in the manufacture of coal-tar colours.

Cupricine. Copper cyanide. A whitish powder insoluble in pure water, readily soluble in NH_3 . It has been recommended medicinally particularly in cases of trachoma instead of the irritating soluble copper salts.

Cupromanganese see MANGANESE ALLOYS.

Cuprosilicon see SILICON.

Curare. The arrow poison of the South American Indians. Many of the constituents are unknown, but there are present some of the strychnine alkaloids. There are different kinds of curare, but even different preparations of the same kind show very different actions. The essential active principle is curarine. It is a strong poison which acts upon the circulatory system. When administered paralysis ensues and death results from asphyxiation. It is very rarely used in medicine on account of the great variability of the preparations, but it is employed to some extent as a remedy in cases of tetanus and epilepsy, and as an antidote in strychnine poisoning.

It usually occurs in the form of a clear or dark-brown extract only partially soluble in water and alcohol.

Curaril. The name given to a strong and stable preparation of curare.

Curcuma see **TURMERIC**.

Cyanogen compounds. The metallic compounds of cyanogen are described under the respective metals.

The methods for the manufacture of important alkali cyanides are being greatly improved.

HYDROCYANIC ACID. HCN . This acid was formerly prepared by heating potassium ferrocyanide $\text{K}_4\text{FeC}_6\text{N}_6$ (see **IRON COMPOUNDS**) with dilute H_2SO_4 , HCN distills over and is collected in the receiver as an aqueous solution. At present this method is extensively used, but there are also numerous new methods which have appeared, of which the most important will be here described. For others compare the article on **POTASSIUM CYANIDE** under **POTASSIUM COMPOUNDS**, and also that on **SODIUM CYANIDE** under **SODIUM COMPOUNDS**.

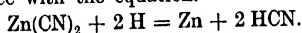
A number of new methods have been evolved with the object of separating cyanogen from coal-gas by a wet process, in which ferrous salts are used to absorb the cyanogen. These are then further treated to recover the cyanogen. According to Germ. Pat. 141624 pure HCN is prepared from coal-gas, blast-furnace gases and coke oven gases by treating them with a mixture of carbonates, hydroxides and oxides of Mg , Al , Sn , Pb and Mn on the one hand and oxides, hydroxides or carbonates of the alkalis or alkaline earths on the other. The cyanides in solution or suspension are heated, when HCN is set free without the addition of acids.

Germ. Pat. 144210 treats of the absorption of the cyanogen from the gases in much the same way, with the addition, however, to the absorption mixture of ferrous oxide free from ferric oxide. Germ. Pat. 151820 deals with the same process, with certain modifications. According to Germ. Pat. 151820 cyanogen compounds may be obtained from gases containing NH_3 by treatment with iron compounds. An improvement is described in Germ. Pat. 162419.

The English Pat. 24456 (1902) starts from ferrocyanide which is distilled with dilute H_2SO_4 or HCl , the temperature in the reflux condenser being kept at 40° . This process differs, only slightly from the method, at that time in general use, of obtaining this substance from potassium ferrocyanide. In this well known reaction, the so-called **EVERITT** salts are left as a residue, which consist of potassium ferric ferrocyanide. Germ. Pat. 150551 and 153358 tread of a method for dissolving the **EVERITT** salts (regeneration of potassium ferrocyanide), after oxidation, by boiling with alkaline lyes, a process, which it is possible to carry out readily on a commercial scale. According to these patents the ferric ferrocyanide salts are boiled with caustic alkalis or solutions of alkaline carbonates, air being simultaneously led into the mixture. In the attempt to make practical use of the **EVERITT** salts by oxidizing them to Prussian blue (ferric ferrocyanide) and this again by boiling with alkali into potassium ferrocyanide, so much time is required when the ordinary oxidizing agents (nitric acid, chromic acid, ferric chloride or ferric sulphate) are used that it is practically impossible to carry out the process. According to Germ. Pat. 156397 the oxidation goes very rapidly, if effected by air. This can be done if while the precipitate is being boiled with an oxidizing agent, air is pumped into the mixture. (Compare this with the two preceding patents.)

According to Amer. Pat. 746876 calcium ferrocyanide should be used to prevent the formation of **EVERITT** salt. The crystallised Ca salts are in this case dissolved in H_2O and heated with H_2SO_4 .

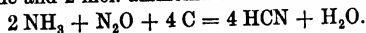
According to English Pat. 24920 (1901) it is recommended to start from insoluble cyanogen compounds, more especially the iron cyanides. The neutral or acid cyanide compounds are boiled with a mercuric compound, e. g. HgCl_2 , and the mercuric cyanide obtained is decomposed by distillation with an acid, when the HCN escapes. If the cyanide used is alkaline, it must be first neutralized before treating with the mercury compounds. Insoluble ferrocyanide compounds are rendered soluble and at the same time neutralized, by treating with caustic alkalies. A method not differing greatly from the last mentioned process is that protected by the Germ. Pat. 141024. The additional Germ. Pat. 147579 advises starting, not from alkaline ferrocyanides, but from ferrocyanides of the alkaline earths, and the use of an acid for distillation which forms an insoluble salt with the metal. In this way the undesired formation of alkali in the HgCl_2 solution is avoided. A further (additional) patent, Germ. Pat. 162362, is based upon the fact that the recovery of the HgCl_2 solution for use in further processes can be simplified by separating the iron compounds before distilling off the HCN . To achieve this the decomposition is carried out in presence of alkalies, so that all the Fe of the iron-cyanide compounds is precipitated as $\text{Fe}_2(\text{OH})_6$. The mercury cyanide solution is separated from the precipitate before decomposing with acids. The Germ. Pat. 157490 renders it possible to make use of mercuric oxide and mercuric sulphate in the process described in the above paragraph. This was formerly impossible, since a large amount of the Hg compound remained in the alkaline iron-containing slime and could only be recovered from this with great difficulty. According to the patent mentioned, the slime is treated with a solution of MgCl_2 . The HgO is dissolved while the $\text{Fe}_2(\text{OH})_6$ remains unaltered. The method of the Germ. Pat. 132294 starts from metallic cyanides, that is from cyanides, ferrocyanides or sulphocyanides of the heavy metals, which are heated in dry hydrogen to 500° . HCN is formed in accordance with the equation.



If a sulphocyanide be used a finely divided metal must be added to combine with the S.

According to Amer. Pat. 719223 the carbonate of an alkaline earth metal is heated in presence of carbon and the substance subjected to the action of N. The cyanide so formed is treated with acetic acid. HCN escapes, and the acetate of the alkaline earth is left. The acetate is converted into acetone. See ACETONE. The Germ. Pat. 151644 treats of the preparation of cyanogen compounds from atmospheric nitrogen, carbon, alkalies, and alkaline earths. Concerning the most important process for obtaining cyanogen compounds from atmospheric nitrogen (FRANK'S process) see CALCIUM COMPOUNDS No. 7 and under POTASSIUM COMPOUNDS No. 9.

According to Germ. Pat. 132999 HCN is obtained by passing a mixture of 1 mol. nitrous oxide and 2 mol. ammonia over red hot carbon.



According to Germ. Pat. 151130 a mixture of NH_3 and gaseous hydrocarbons, e. g. water gas, is passed in a perfectly dry condition over a suitable catalytic medium, such as strongly heated platinized pumice stone. The yield of HCN is only satisfactory when the gas mixture contains free hydrogen.

Finally mention must be made of BUEB'S PROCESS for obtaining HCN from the refuse of molasses. The sugary residue is heated in absence of air until gases are evolved. The gases are heated to the temperature necessary for the formation of cyanogen, after which they are cooled and freed from NH_3 . After this the cyanogen is usually passed into sodium or potassium hydroxide solution for the direct preparation of the cyanides. Pure hydrocyanic acid is obtained from crude HCN by distillation and drying

over CaCl_2 . It is a colourless mobile liquid, S. G. 0.6967, which solidifies in the cold, and then melts at -13.8° , B. P. 26.5° . It has a penetrating acid, smell which in very weak solution only is suggestive of bitter almonds. It is extremely poisonous. In H_2O and alcohol it is soluble in any proportion.

TEST. For estimating HCN in aqueous solution LIEBIG's volumetric method is the best. 10 to 15 cc (according to the strength) are taken and diluted until the solution contains not more than 0.1 g HCN. 5 cc normal NaOH and 5 g NaHCO_3 are added and the solution diluted to 50–60 cc. AgNO_3 solution ($1/10$ N.) is added so long as the precipitate formed redissolves on shaking. When the solution becomes opalescent the titration is ended.

1 cc AgNO_3 solution corresponds to 0.0054 g HCN.

Cyclocitral see CITRAL.

Cylline. A disinfectant first introduced in England. It is a dark-brown liquid with a strong smell of crude carboic acid. It is really a coal-tar oil made soluble by the help of fatty acids and resin acids. It is recommended as being non-poisonous and non-irritating but in spite of the claims made by the manufacturers this cannot be, because of its content of phenols (35 %) and of pyridine bases.

Cystopurine. A double salt of 1 mol. of hexamethylenetetramine and 2 mol. of sodium acetate.

It is prepared according to the method described in the Amer. Pat. 852993 and is probably a mixture. Cystopurine is employed as a urinary antiseptic and as a prophylactic for gonorrhoea.

D.

Dammar. A resin obtained from various trees, more particularly from *Engelhardtia spicata* bl., *Schorea Wiesneri*, &c.

It forms colourless or pale yellow clear lumps (frequently clouded by bubbles) which are harder than colophony, though softer than mastic, copal and sandarac. Another species, the New Zealand Dammar belongs to the copals (Kaurie copal). Dammar has a specific gravity of 1.04–1.12; M. P. 120°C .; acid number 20–35; acetyl-acid number 50.52–51.80; acetyl-ester number 81.56–83.06; acetyl saponification number 132.08–134.86; water 0.1–1 %; ash 0.01–1 %. It is completely soluble in fatty and essential oils, benzene, chloroform, and carbon-bisulphide, partly in alcohol, toluene, acetone, aniline, petroleum ether, and acetic acid.

Solutions of the various Dammar resins in turpentine form hard colourless rapidly drying varnishes (Dammar varnishes) specially adapted for varnishing oil paintings. Dammar is also used in medicine for making sticking plaster.

Dasymeter. For the automatic determination of the S. G. of gases, especially of coal-gas. The gas continuously streaming through the globe of the apparatus indicates all variations of the S. G. with an accuracy of 0.005.

Degras (TANNING GREASE, LEATHER GREASE). The fat obtained in tanning chamois leather (see "CHAMOIS DRESSING") which consists of oxidized oil. The *Degras* is taken from the leather with a knife and the leather washed with a solution of soda or potash. The mixture so prepared is decomposed with H_2SO_4 . A purer form of *Degras* is obtained by a French method and sold as *Moellon*. The process is to tan the leather for a shorter time than

is usual in white dressing and to press the oxidized oil from the leather under water at a high pressure. As the demand for degras is greater than the supply there are tanneries in which inferior skins are subjected to repeated chamois dressing with the sole object of obtaining *Degras*. So-called artificial degras is a mixture of *Chamois-Moellon* and artificially oxidized oil; frequently also Moellon is not used and the product is obtained from oxidized oil, oleic acid, talc, lanoline, &c.

The Germ. Pat. 149822 is concerned with the oxidizing action of ferments on oils with the object of producing *Degras* and similar products: A culture of denitrifying bacteria (e. g. cheese bacteria) is mixed with oil, a solution of salpetre and nutrient media, the whole well aerated and finally the oil washed out. The oil is then strongly acid and of much greater consistency and can be used as *Degras*.

Degrasine a concentrated glandular extract sold in the form of tabloids.

Delalot's alloy see MANGANESE ALLOYS.

Delta metal see COPPER ALLOYS.

Denaturation. Spirits are the principal articles which are subjected to denaturation. Spirits which are to be used for industrial purposes, are denatured. The denaturation is carried out in order to make the substance unsuitable for human consumption, but the process must be carried out so that it does not in any way interfere with the uses for which the substance is intended.

In Germany, salt is mixed with iron oxide or red chalk and wormwood powder when it is to be used as a food stuff or manure. In other cases GLAUBER's salt, kieserite, charcoal, ashes, soap powder, oils, petroleum, alum, ferrous sulphate, carbolic acid, &c. are added.

Spirits are denatured with wood spirit (methyl alcohol), pyridine bases, rosemary oil, lavender oil, turpentine oil, animal oil, acetone, benzine, benzene, solvent naphtha, &c. The wood spirit used must be colourless or only slightly yellow and almost completely volatile below 75°; it must be miscible with water without noticeable milkiness in all proportions and not contain more than 30 % acetone.

In Germany since (the year 1887) the completely denatured spirit is treated with a mixture which consists of four parts of wood spirit of a certain degree of impurity and 1 part of pyridine bases. 2½ litres of this mixture are added to 100 litres of pure alcohol. Since the 1st Oct. 1902 another process for completely denaturing spirits has also been allowed. In this 1½ litre of the above described denaturing agent, 2 litres benzene and 0.25 litres of a crystal violet solution (hexa methyl-p-rosaniline hydrochloride) are added to every 100 litres of pure alcohol. The amount of the dye added is only one millionth part of the denatured spirits.

Germ. Pat. 144483 aims at the preparation of a denaturing agent for spirits from crude coal-tar by mixing equal parts of 95 % spirits and decanted coal-tar with the aid of a stirring apparatus and drawing off the spirits after settling. 1 part of this product is sufficient for the denaturation of 100 parts of spirits, 1—10 parts of commercial benzene being also added.

The Russian Privil. 6709 and 6710 which make use of tartar emetic and mustard oil on of carbon disulphide and aldehyde, have no prospect of becoming technically important.

For the direct preparation of denatured spirits by the fermentation of "Mash" according to the Germ. Pat. 139387, see ALCOHOL.

TEST. In order to detect the presence of methyl alcohol in essences, brandy, tinctures, and liquid extracts, R. PETERS writes as follows (Pharm. Centralh. 1905, 521; Chem.-Ztg. 1905 Repert. 218). The wood spirit for denaturing

alcohol for industrial purposes must contain 25 % acetone the presence of which can be shown in the following way:— 10 ccm of the alcoholic essence &c. are treated with water and 20 cc of this mixture distilled off with a small flame. 10 cc of the well-shaken distillate are treated with 1 cc of a freshly prepared 1 % solution of sodium nitroprusside (which has been kept in the dark) and 2 cc — with strongly acid solutions even more — of a 4 % sodium hydroxide solution. If acetone is present a strong red colouration is formed the depth of the colour depending on the amount of acetone present. If acetone is not present the mixture merely turns yellow. Colourless preparations such as essence of camphor &c. may be tested directly without previous distillation.

Denitration. The decomposition of nitro-sulphuric acid into its constituents, H_2SO_4 and HNO_3 , and the separation of these from each other is carried out in iron towers lined with acid-resisting stone and filled with spherical or conical masses which increase the active surface. The H_2SO_4 remains in the liquid state and runs away from the bottom of the tower, whilst the HNO_3 escapes at the top in the form of vapour and is condensed in earthenware apparatus. A special condensation tower is also provided in which the last traces of gas are retained.

In order to lessen the inflammability of nitrocellulose (used in the preparation of artificial silk, celluloid &c.), the threads or films are treated with metallic salts which themselves can be oxidized to a higher state. Thus cuprous chloride has a strong denitrating action, and such is the case with the salts of iron, manganese, tin, &c. It is advisable to add also substances which cause the nitrocellulose to swell, e. g. alcohol, ether, acetone, glycerine, &c.

For further details see **SILK, ARTIFICIAL**.

Denitrating Plants:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Density see **SPECIFIC GRAVITY**.

Derizine. A name applied to Florizine obtained from Castor oil (q. v.).

Dermatol. A basic bismuth salt of gallic acid, $C_6H_2(OH)_3CO_2Bi(OH)_2$, prepared from gallic acid and bismuth nitrate.

It is a fine yellow powder insoluble in water, alcohol and ether. It is used medicinally for the treatment of wounds and skin diseases on account of its antiseptic, drying and non-irritating properties. It is also used as a remedy for perspiring feet in the form of a 20 % powder, and is also prescribed for internal use as a preventive of diarrhoea.

Dermol. The bismuth salt of chrysophanic acid. Formerly prescribed for external use in skin diseases. It now seems to be but little used.

Determining vessels:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Dewar vessels. These are double-walled glass vessels. The space between the inner and outer walls is rendered vacuous so far as is possible, in order to lessen heat-radiation, which object is also furthered by silvering the internal surfaces. They are used for storing liquid air. In them the latter may be kept for a long time without suffering appreciable loss through evaporation.

Dextrine (STARCH GUM, BRITISH GUM). Usually prepared by gently roasting starch (at 160—200°). If a small amount of acid be present a temperature of 120—140° is sufficient and a clearer product is obtained.

In the dry process drums with stirrers or roasting pans are used, the temperature being kept constant by means of oil, steam, or air baths. The dextrine thus obtained is usually termed "roast gum".

In the second process 0.1—0.15 % of the weight of starch of HCl or HNO₃ is added, the mixture dried at 50°, and then heated to temperatures between 110° and 140° according to the desired degree of clearness. The roasting is usually carried out in ovens fitted with shelves and heated by hot air. The product thus obtained is sold as dextrine gum.

The Amer. Pat. 755390 aims at the manufacture of dextrine from peat. The raw material is mixed with twice the amount of H₂O and then heated in an autoclave for 2 hours to 160—200°, so that the cellulose of the peat is converted into achroodextrine.

Dextrine is not a simple product; the different qualities have not only different colours but also different adhesive properties. The value of dextrine is due to its adhesive properties, and for this reason, it is used as a substitute for gum arabic, for pasting, for glazing paper, for thickening dyes and inks, for calico-printing, and for the manufacture of matches, &c.

The Germ. Pat. 155567 protects the preparation of a solid powdery compound of dextrine and formaldehyde which is soluble in H₂O and is said to be used medicinally.

Dextrines:

R. Preston & Co., Bury, Lancs.

Dextrose see GLUCOSE.

Diamonds, artificial. The problem of obtaining crystallized carbon as in the transparent form of diamonds was, in principle, first solved by MOISSAN. At the high temperatures produced in the electric furnace he saturated molten iron with carbon and then suddenly cooled the mass. The enormous pressure thus generated caused the carbon to crystallize. HOYERMANN's process is simpler, *Chem.-Zeitung* 1902, page 481. Instead of an electric current he makes use of GOLDSCHMIDT's method employing a mixture of Fe₂O₃ and powdered Al, which when started with an ignition pill raises the Fe to the temperature necessary to dissolve the C. In the rapidly cooled regulus are found small diamonds which are visible to the naked eye. Compare THERMITE for GOLDSCHMIDT's process. v. HASLINGER's process (*Naturf. Vers. in Karlsbad* 1902; *Monatshfte für Chemie*, vol. 23, page 817) is deserving of special interest as approaching the natural process. HASLINGER started with kimberlite as a basis. This stone is found in South Africa. In it the diamond is found and was probably formed from it. A mixture corresponding to the composition of kimberlite was made, to which was added 2% of finely ground graphite and the whole fused. The mass was cooled and treated with ammonium fluoride and H₂SO₄. Perfectly clear and transparent diamonds forming beautifully proportioned octahedra of an average size of 0.05 mm were found inside in great quantities.

Further experiments for making artificial diamonds have been made by LUDWIG (*Chem.-Zeitung* 1902, p. 617 and *Repert.* page 160), but they are not yet complete or at any rate have not been published. According to LUDWIG, high temperature, high pressure and especially rapid cooling of the reaction mixture are necessary for the formation of diamonds.

In order to prepare diamonds by MOISSAN's method, W. CROOKES in a lecture gave the following details. Perfectly pure iron, free from S, Si, P, &c., is mixed with pure sugar charcoal in a graphite crucible, which is then heated to 4000° for some minutes in an electric furnace. The Fe becomes thin and partly volatilizes, the crucible is then suddenly cooled to red heat by placing it in cold H₂O, which causes the iron to form a crust which exerts an enormous

pressure on the still-molten interior. Under the influence of this pressure small particles of the carbon then crystallize in the form of diamonds. All these processes and others which have been given are at present only of scientific interest and of no value for industrial purposes, the cost being too great in proportion to the yield and size of the diamonds

Dianil colours. Under this name the "Hoechst Farbwerke" supply a series of substantive cotton dyestuffs which may be used directly, developed or treated with metallic salts after dyeing. They yield a wide range of colours. Dianil yellow G, 3 G and R for example, are substantive mono-azo dyes prepared apparently from primuline or dehydrothiolutidine and a β -diketone.

Diaphragms. Porous separating walls which are very often used in electro-chemistry for separating the anode and cathode chambers. These diaphragms are usually made of clay, porcelain, cement, asbestos prepared with sand or kieselguhr, soap plates or other materials. The porosity is often brought about by mixing finely divided organic substances (e. g. coal dust) with the material which is then burnt; in this way gases are evolved which cause the formation of pores.

Among the numerous new processes for the manufacture of diaphragms may be mentioned that of the firm BERNFELD & Co. (Leipzig) who have succeeded in preparing a diaphragm of asbestos the pores of which do not become blocked. It is said not to be dissolved by hot neutral and alkaline liquids. This result is said to be attained by carefully igniting the asbestos pulp at a temperature far below that at which asbestos melts.

According to the Germ. Pat. 143591 porous diaphragms may be obtained from dry pressed cement-like substances which after moulding are very carefully treated with H_2O .

The Germ. Pat. 143938 treats of the preparation of very porous but also very resistant diaphragms of wood: white, light wood is first treated with an ammoniacal solution of copper in order to dissolve out the cellulose, afterwards successively with caustic alkalies, with HCl, hot H_2O , cold H_2O , and finally with hot alcohol.

Diaphtherine. A compound of 1 mol. o-phenolsulphonic acid and 2 mol. o-oxyquinoline. A crystalline powder with a salty taste and a slight odour recalling that of phenol and saffron. M. P. 85° . It is used externally in 0.5 % solution as an antiseptic.

Diastase. The diastases are ferments (q. v.) which convert starch into sugar. Diastase is prepared from malt (q. v.). It is no longer used solely in the brewing and alcohol industries but also in bakeries &c. In baking it is employed for the purpose of increasing the "lightness" of the preparations and for preventing them from drying too quickly.

For this purpose diastatic preparations in the form of soluble syrups are sold. Concerning them see Germ. Pat. 113602, 148844 and 151255. According to these, the diastase is extracted from malt in the cold, evaporated *in vacuo* at a low temperature and the residue converted into maltose. The extract is prevented from decomposition (according to the first-named patent) by treatment with CO_2 .

Germ. Pat. 173232 protects a method for the preparation of pure diastase. The malt is extracted with cold water, and the extract filtered through infusorial earth. The filtrate is then fermented with yeast cultures in sterile vessels, filtered when the fermentation is complete and the filtrate after removing all soluble substances by dialysis, concentrated *in vacuo* and finally dried. The product is a greyish or white powder of great diastatic power.

Diastatic preparations also find considerable employment in the textile industries for finishing (dressing), that is to say, for the removal of starchy deposits by conversion into sugar.

A syrupy preparation of this kind is sold commercially under the name of DIASTOFOR. This is used for removing starchy matters &c. from textiles. One method, protected by patents, is to print the fabric first with diastofor and then with alkaline indigo preparations. The colour is developed in the usual way.

Diastofor see **DIASTASE**.

Diatomites The registered name (Germany) for a preparation of infusorial earth obtained by heating. It is very porous and has a S. G. of 0.3.

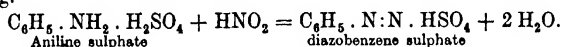
Bricks of this material can be made of any desired shape. They can be heated to a red heat without undergoing alteration and are not attacked by water, steam, dilute acids or alkalies. They are good non-conductors of heat and should find a useful place in chemical industry.

Diazoamido dyes. If dehydrothiitoluidine $\text{H}_3\text{C} \cdot \text{C}_6\text{H}_3 \begin{array}{c} \diagup \text{N} \\ \diagdown \text{S} \end{array} \text{C} \cdot \text{C}_6\text{H}_4 \cdot \text{NH}_2$, be

combined with disazo substances, dyes are obtained which can hardly be classed as azo-derivatives but are more probably diazoamido compounds, seeing that they cannot be further diazotized. The dyes belonging to this class are, however, often classed with the thio-benzenyl dyes to form the group of the thiazol dyes.

For example the yellow Nitrophenine, which dyes cotton directly, is formed by the action of p-nitraniline on dehydrothiotoluidine-sulphonic acid.

Diazo compounds. A class of organic compounds with the group $—N=N—$ in which one of the free valencies is attached to an aromatic hydrocarbon group while the other is united to an acid radicle. The diazo compounds are formed by the action of nitrous acid on the salt of an aromatic amido derivative, e. g.



The diazo compounds (especially the free bases) are very unstable but are very reactive. Most of them are explosive. According to the French Pat. 323981 the stability of the solutions of many diazo bodies is considerably raised by the addition of salts (especially cryst. GLAUBER's salt) but experiments (Ztschr. f. Farben- und Textil-Chemie 1903, 225) do not exactly recommend the employment of this patent.

Dichlorhydrine see CHLORHYDRINE.

Didymium. This substance was for a long time looked upon as an element, but is now divided into the two components Neodymium Nd and Praseodymium Pr. It is not yet decided whether the two last-named substances are really elements or not. In practice didymium is still regarded as an element and its compounds are described as if they were really those of an element. The didymium compounds are used for the manufacture of incandescent gas mantles. The isolated neodymium nitrate has been recently recommended for the purpose of rendering glass colourless.

Diffusion. If two substances are in contact — more particularly gases or liquids — or if they are separated from one another by a porous membrane, they diffuse, that is as a result of the molecular forces the smallest particles

of the one pass over into the other. The diffusion through membranes is termed Osmosis.

With gases the rate of diffusion is, approximately, inversely proportional to the square roots of the densities.

So far as diffusion is concerned two classes of dissolved substances are recognized, crystalloids and colloids. Crystalloids are those substances, salts, many acids, alcohols, &c. which diffuse readily through membranes; in general they are compounds which are able to form crystals. The colloids do not diffuse or only very sparingly. To this class belong the albuminoids, gums, rubber, starches, silicic acid, ferric hydroxide, aluminium hydroxide, &c.

Diffusion is largely employed on a manufacturing scale see "COLOUR EXTRACTS", "TANNIN EXTRACTS", "MOLASSES" (osmosis process), "TANNIN" and "SUGAR MANUFACTURE".

1. Coefficients of diffusion of some of the gases ¹⁾.

Gas	Diffuses in	Coefficient of Diff. in sq. cm/sec	Gas	Diffuses in	Coefficient of Diff. in sq. cm/sec
Air	carbonic acid	0.13561	Ethane	hydrogen	0.458
"	oxygen	0.17753	Hydrogen	carbonic acid	0.53836
Carbon dioxide ..	air	0.14231	"	oxygen	0.7086
"	oxygen	0.18022	Methane	hydrogen	0.625
"	hydrogen	0.54367	Oxygen	carb.monoxd.	0.187
Carb. monoxide ..	oxygen	0.18022	"	air	0.178
"	hydrogen	0.64223	"	hydrogen	0.72167

2. Coefficients of diffusion of various inorganic compounds in dilute aqueous solution.

(The coefficient of diffusion D gives the amount of substance in grms which, at the temperature t, would pass in one day through a section of 1 square centimetre when two sections 1 cm apart show the difference of concentration 1 (grm in 1 ccm).)

Name of substance	t	D	Name of substance	t	D
Ammonia	4.5°	1.06	Potassium chloride	9.0°	0.66
Ammonium chloride	17.5°	1.31	Potassium hydroxide	13.5°	1.66
Barium chloride	8.0°	0.65	Potassium nitrate	7.0°	0.92
Calcium chloride	8.5°	0.70	Silver nitrate	7.5°	0.90
Copper chloride	10.0°	0.43	Sodium chloride	6.0°	0.75
Copper sulphate	10.0°	0.21	Sodium hydroxide	8.0°	1.06
Hydrochloric acid	0.0°	1.4	Sodium carbonate	4.5°	0.44
Lead nitrate	12.0°	0.70	Sodium nitrate	13.0°	0.90
Magnesium sulphate	7.0°	0.30	Sodium thiosulphate	10.5°	0.54
Nitric acid	9.0°	1.75	Sulphuric acid	7.5°	1.04
Potassium chloride	11.0°	1.84			

Diffusing apparatus in copper and iron:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Diffusing apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückonstr. 6b (see advts.).

Digalene (DIGITOXINUM SOLUBILE). Obtained by a special process from the leaves of *Digitalis*. It forms a white amorphous substance which is brought

¹⁾ This as well as the next table are taken from BUCHKA'S Physikalisch-chemische Tabellen der anorganischen Chemie. Stuttgart 1895.

into commerce in an aqueous solution with 25 % glycerine. In its action composition and chemical properties the product resembles the crystallized digitoxin, but it has the advantage over the latter substance in being more easily soluble. It is said to be non-irritating when administered subcutaneously or by the mouth and in this respect is unlike the crystallized digitoxin.

1 ccm digalene contains 0.0003 grm. digitoxin, or 1 ccm corresponds to 0.15 grm *Digitalis* leaves. It is brought into commerce in small bottles of 15 ccm and is said to keep well in this form.

Digitaline. Under this name are grouped together the active constituents of the red foxglove (*Digitalis purpurea*). It is certain that the substance is not a single alkaloid. As a matter of fact these substances contain no nitrogen and so cannot be termed alkaloids at all.

The DIGITALIN. PUR. PULV. GERMAN. (German amorphous digitaline) is extracted by alcohol from the seeds or leaves of *Digitalis*. After the alcohol has been distilled off the extract is diluted with H_2O , purified with lead acetate, and the digitaline precipitated from the filtrate by tannic acid. The tannate is then decomposed with lead oxide and the digitaline extracted with alcohol. After purifying, drying, and powdering, it forms a yellowish-white amorphous powder. It is used in doses of from 0.001—0.002 grm 2—3 times daily; max. single dose 0.004 grm, max. daily dose 0.02 grm.

Digitoxin $C_{34}H_{44}O_{11}$ is a crystalline powder; it is prepared by extracting the leaves of *Digitalis* at first with cold H_2O to remove the impurities, and then treating with 60 % alcohol which dissolves out the digitoxin. It is insoluble in H_2O , sparingly soluble in cold, readily in hot alcohol, and in $CHCl_3$. As it is not a mixture of different substances like the above mentioned digitaline, but appears to be a real compound it is coming more into use medicinally, usually for heart disease. Single dose 0.00025 grm, daily dose (maximum), 0.002 grm. It can be swallowed, or injected subcutaneously. Recently it has been brought into commerce in the more convenient tablet form.

The French digitaline, the Kilian digitaline, digitalcin, and digitonin cannot here be treated of, as they are of very little importance.

Digitoxine see DIGITALINE.

Dimethylaniline see ANILINE DERIVATIVES.

Dimethylbenzene see XYLENE.

Dimethylsulphate see METHYL COMPOUNDS.

Dimethylxanthine see THEOZINE and THEOPHYLLINE.

Dimopyrane. Trade name for a preparation intended to replace Pyramidone (q. v.).

Dinas bricks. A special class of fire-proof stones, made from sand, milk of lime and a cementing material. The mixture is moulded and pressed in iron moulds made in halves. During burning the lime sinters and so forms a kind of cement. Of the many suggested improvements the one described in Germ. Pat. 69318 may be mentioned. According to this method gypsum mixed with $Al_2(SO_4)_3$ or $MgSO_4$ is used instead of the lime. According to Germ. Pat. 150628 the lime is replaced by Portland or some other cement which acts as a binding substance and after burning converts the quartz grains into polysilicates.

Dinitrobenzene $C_6H_4(NO_2)_2$. The meta derivative is the most important of the three isomers. It is prepared like nitrobenzene (q. v.) but heat is supplied to facilitate the reaction. The other isomers are formed in small amounts and can be separated by fractional crystallization and distillation.

It forms colourless, thin, rhombic needles, M. P. 89.9, insoluble in water, readily soluble in alcohol and ether. In the impure state it has a yellowish tinge. On reduction it yields first m-nitraniline and finally m-phenylene diamine. It is mainly used in the preparation of the latter compound.

Dinitroglycerine see NITROGLYCERINE.

Dinitrotoluene. $C_6H_3 \cdot CH_3 \cdot (NO_2)_2$. The asymmetric (meta) dinitrotoluene is of commercial importance ($CH_3:NO_2:NO_2 = 1:2:4$). So also is the p-dinitrotoluene.

The former is obtained by the direct nitration (without cooling) of toluene with a mixture of H_2SO_4 and HNO_3 .

Dinitrotoluene:

Sprengstoff A.-G., Carbonit, Hamburg.

Dionine = Ethylmorphinehydrochloride. Ethyl morphine is prepared by the action of ethyl iodide on an alkaline solution of morphine, and the salt by neutralizing with HCl.

A white crystalline powder soluble in water, readily in alcohol, almost insoluble in ether and $CHCl_3$. It is used medicinally as a substitute for morphine and is administered internally and subcutaneously. It is recommended for the irritating cough accompanying certain lung and laryngeal complaints.

Dioxybenzene see PYROCATECHIN, RESORCINE and HYDROQUINONE.

Diphenal see "PHOTOGRAPHIC CHEMICALS".

Diphenylamine $(C_6H_5)_2NH$. Obtained by heating aniline with aniline salts (aniline hydrochloride) to 210–240° C. in autoclaves. The product of the reaction is treated with HCl and then with excess of H_2O , so that the diphenylamine hydrochloride first formed is again decomposed and the free base swims on the surface where it rapidly solidifies. It is purified by washing and fractional distillation. Monoclinic colourless leaves, M. P. 54°; B. P. 310° C. almost insoluble in water, readily soluble in alcohol, ether and benzene. It has an agreeable smell, and a sharp, burning taste. It is a very weak base and its salts decompose when heated with water. It is used in the preparation of various tar colours.

TEST. The commercial product should be nearly colourless, not greasy, have no disagreeable smell, melt at the proper temperature and should not rapidly turn brown in the air. It is tested for aniline by shaking the powdered substance with a solution of bleaching powder, when it should not turn violet.

Diphenylmethane-dyestuffs. The parent substance of this class of dyes is Diphenylmethane $(C_6H_5)_2 \cdot CH_2$. For further particulars see the articles "AURAMINE" and "PYRONINE-DYES".

Diphenylnaphthyl-dyestuffs. A class of dyestuffs the members of which are derived from Diphenylnaphthylmethane. $C_{10}H_7 - CH \begin{matrix} \nearrow C_6H_5 \\ \searrow C_6H_5 \end{matrix}$ Obtained chiefly by the action of substituted naphthylamines on tetramethyldiamido-

benzophenone or on tetramethyldiamidobenzhydrol in the presence of dehydrating agents.

Disazo-dyestuffs. (Tetrazodyestuffs.) A class of dyestuffs of which the members contain two azogroups ($-\text{N}=\text{N}-$) (see AZODYESTUFFS). These may be obtained in various ways; e. g. by the combination of an azodyestuff with another molecule of a diazo compound; or by diazotising an amido-azodyestuff and "coupling" with another molecule of a phenol or an amine; or, finally, by diazotising a diamine and coupling the two molecules of tetrazo compound with 2 mols. of a phenol or an amine. In the latter case, the two molecules may belong to different phenols or amines. The disazo-dyestuffs obtained from diamines are particularly remarkable for their property (possessed by nearly all the members of the group) of dyeing cotton directly (substantively), i. e. without the use of mordants.

Disintegrators.

Disintegrators:

W. Stann, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.
Max Friedrich & Co., Leipzig-Plagwitz 17.

Distillation see "FRACTIONATING", "RECTIFICATION".

Distilling apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).
Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Distilling apparatus of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Distilling Plant:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Disulphuric acid see FUMING SULPHURIC ACID.

Dithion = sodium dithio-salicylate. It acts as an antiseptic and antipyretic. Probably now only used in veterinary surgery.

Diuretine = Theobromine-sodium-salicylate. An alkaline solution of theobromine is mixed in molecular proportions with a solution of sodium salicylate, the mixture filtered and evaporated to dryness.

White, amorphous, odourless powder, readily soluble in H_2O . It is prescribed in gout, dropsy and diseases of the heart and kidneys. It acts as a powerful diuretic.

Donarite see "SAFETY EXPLOSIVES".

Dormiole = Amylenechloral. $\text{CCl}_3 \cdot \text{CH}(\text{OH})\text{O} \cdot \text{C}_5\text{H}_{11}$. Obtained by mixing 10 parts of anhydrous chloral with 6 parts amylen hydrate.

Colourless, oily liquid smelling like camphor, S. G. 1.24. Does not mix with cold H_2O . Soluble in any proportion in alcohol, ether, acetone and the fixed oils.

It is prescribed internally as a good and harmless soporific, for instance in cases of heart disease, neurasthenia, insanity, &c.

Double protar see "PHOTOGRAPH".

Dowson gas see "WATER GAS".

Dualine see "DYNAMITE."

Blücher.

Dragon's blood (SANGUIS DRACONIS; RESINA DRACONIS). A collective name for several similar vegetable gums of dark brownish-red colour, which are non-transparent and brittle. In European commerce there are only a few kinds of dragon's blood of importance. The chief of these is the East Indian. It is derived from the palm *Daemonorops* (*Calamus*) *Draco* from the fruit of which it exudes. The best quality is found in grains which are kneaded together to balls (tears). The "dragon's blood in tears" is more valuable than that obtained by treating the fruit with steam, the so-called "dragon's blood in cakes". After this operation the fruit is broken up and melted by gentle heating; in this way a third quality "the dragon's blood in sticks" is obtained.

The different kinds of dragon's blood have a dark-red to blackish-red colour, are non-transparent, and possess a sweet, slightly rasping taste. The real dragon's blood resin is soluble in alcohol, benzene, carbon disulphide, chloroform, and petroleum, but almost insoluble in ether and turpentine oil. The value of the different kinds is judged according to the depth of the dark-red colour of the streak on rough paper. It is used for the preparation of red lakes and varnishes.

DRUGS

Table A.

Latin Name	English Name
<i>Agaricus</i>	Larch Polyporus
<i>Aloe</i>	Aloes
<i>Ammoniacum</i>	Ammoniacum
<i>Amygdalae</i>	Almonds
<i>Amylum</i>	Starch
<i>Anime</i>	Gum Animi
<i>Anthophylli</i>	Mother Cloves
<i>Araroba</i>	Araroba
<i>Asa foetida</i>	Asa foetida
<i>Balsamum canadense</i>	Canada Balsam
" <i>Copaivae</i>	Balsam of Copaiba
" <i>peruvianum</i>	Balsam of Peru
" <i>tolutanum</i>	Balsam of Tolu
<i>Benzoe</i>	Gum Benzoin
<i>Boletus cervinus</i>	Hart's Truffles
<i>Bulbus Alii</i>	Garlic
" <i>Scillae</i>	Squill
" <i>Victorialis longae</i>	Long-rosted Garlic
<i>Camphora</i>	Camphor
<i>Canella alba</i>	Canella; Wild Cinnamon
<i>Carrageen</i>	Carrageen (Iceland moss)
<i>Cascara Sagrada</i>	Cascara Sagrada
<i>Cassia fistula</i>	Purging Cassia
<i>Caryophylli</i>	Cloves
<i>Catechu</i>	Catechu
<i>Colocynthis</i>	Colocynth
<i>Colophonium</i>	Rosin (Colophony)
<i>Copal</i>	Copal
<i>Cortex aurantii fructus</i>	Orange-peel
" <i>Angusturae</i>	Angostura Bark or Carony Bark
" <i>Canellae albae</i>	Canella Bark
" <i>Cascarillae</i>	Cascarilla Bark
" <i>Chinae</i>	Peruvian Bark
" <i>Cinnamomi</i>	Cinnamon
" <i>Citri fructus</i>	Lemon-peel
" <i>Condurango</i>	Condurango Bark
" <i>Coto</i>	Coto-bark
" <i>Frangulae</i>	Black Alder
" <i>Granati</i>	Pomegranate Bark
" " <i>radicis</i>	Pomegranate Root-bark

	Latin Name	Englisch Name
<i>Cortex</i>	<i>Guajaci</i>	Guaiacum
"	<i>Mezeri</i>	Mezereon Bark
"	<i>Quassiae</i>	Quassia bark
"	<i>Quebracho</i>	Quebracho Bark
"	<i>Quercus</i>	Oak Bark
"	<i>Quillajae</i>	Soaptree Bark
"	<i>Rhamni Purshiani</i>	Cascara Sagrada
"	<i>Salicis</i>	Willow Bark
"	<i>Sassafras</i>	Sassafras Bark
"	<i>Simarubae</i>	Simaruba Bark
"	<i>Ulm</i>	Elm Bark
"	<i>Winteranus</i>	Winter's Bark
<i>Crocus</i>		Saffron
<i>Cubebae</i>		Cubebs; Java Pepper
<i>Curare</i>		Curare
<i>Curcuma</i>		Turmeric
<i>Dammara</i>		Dammar
<i>Elemi</i>		Gum Elemi
<i>Euphorbium</i>		Euphorbium
<i>Fabae calabaricae</i>		Calabar Beans; Ordeal Bean
"	<i>Tonca</i>	Tonka Beans
"	<i>St. Ignatii</i>	St. Ignatius' Beans (Nux vomica)
<i>Flores</i>	<i>Acaciae</i>	Blackthorn flowers
"	<i>Arnicae</i>	Arnica flowers
"	<i>Aurantii</i>	Orange flowers
"	<i>Cassiae</i>	Flowers of Cassia
"	<i>Chamomillae</i>	Chamomile flowers
"	" <i>romanae</i>	Roman Chamomile flowers
"	<i>Cinae</i>	Wormseed or Semen contra
"	<i>Koso</i>	Kousso flowers
"	<i>Lavandulae</i>	Lavender
"	<i>Malvae</i>	Mallow
"	" <i>arboreae</i>	Hollyhock
"	<i>Naphae</i>	Orange flowers
"	<i>Pyrethri</i>	Pyrethrum (Spanish Chamomile)
"	<i>Rhoeados</i>	Poppy petals
"	<i>Rosae</i>	Rose petals
"	<i>Sambuci</i>	Elder flowers
"	<i>Tiliae</i>	Linden flowers
"	<i>Verbasci</i>	Mullein flowers
<i>Folia</i>	<i>Aurantii</i>	Orange leaves
"	<i>Althaeae</i>	Marsh Mallow
"	<i>Belladonnae</i>	Belladonna
"	<i>Bucco</i>	Buchu
"	<i>Coca</i>	Coca
"	<i>Daturae</i>	Thornapple (Datura)
"	<i>Digitalis</i>	Foxglove
"	<i>Farfarae</i>	Coltsfoot
"	<i>Hyoscyami</i>	Henbane
"	<i>Jaborandi</i>	Jaborandi
"	<i>Juglandis</i>	Walnut
"	<i>Lauri</i>	Laurel or Sweet Bay
"	<i>Laurocerasi</i>	Cherry Laurel
"	<i>Malvae</i>	Mallow
"	<i>Matico</i>	Matico
"	<i>Melissae</i>	Common Balm
"	<i>Menthae crispae</i>	Curled Mint
"	" <i>piperitae</i>	Peppermint
"	<i>Menyanthis</i>	Buckbean
"	<i>Millefolii</i>	Yarrow
"	<i>Nicotianae</i>	Tobacco ...
"	<i>Rosmarini</i>	Rosemary

	Latin Name	English Name
<i>Folia</i>	<i>Salviae</i>	Sage
"	<i>Sennae</i>	Senna
"	<i>Stramonii</i>	Thornapple
"	<i>Trifolii fibrini</i>	Buckbean
"	<i>Uvae ursi</i>	Bearberry
<i>Fructus</i>	<i>Anomi</i>	Allspice, Jamaican Pepper.
"	<i>Anethi</i>	Dill
"	<i>Anisi</i>	Aniseed
"	" <i>stellati</i>	Star Anise
"	<i>Aurantii immaturi</i>	Unripe Oranges ("Issue Peas")
"	<i>Cannabis</i>	Hempseed
"	<i>Capsici</i>	Capsicum; Cayenne Pepper; Red
"	<i>Cardamomi</i>	Cardamoms [Pepper]
"	<i>Carvi</i>	Caraway
"	<i>Cassiae fistulae</i>	Purging Cassia
"	<i>Ceratoniae</i>	St. John's Bread or Algaroba
"	<i>Cocculi</i>	Cocculus indicus
"	<i>Colocynthis</i>	Colocynth
"	<i>Conii</i>	Hemlock
"	<i>Coriandri</i>	Coriander
"	<i>Cumini</i>	Cumin
"	<i>Foeniculi</i>	Fennel
"	<i>Jujubae</i>	Jujubes
"	<i>Juniperi</i>	Juniper berries
"	<i>Lauri</i>	Laurel berries
"	<i>Myrtilli</i>	Whortle berries
"	<i>Papaveris</i>	Poppy heads
"	<i>Petroselini</i>	Parsley seed
"	<i>Phellandrii</i>	Fineleaved Water Hemlock, or Water
"	<i>Piperis</i>	Black Pepper [Fennel]
"	<i>Rhamni catharticae</i>	Buckthorn berries
"	<i>Sabadillae</i>	Sabadilla
"	<i>Sambuci</i>	Elder berries
"	<i>Silybi</i>	Proly. Milk Thistle
"	<i>Tamarindi</i>	Tamarinds
"	<i>Vanillae</i>	Vanilla
<i>Fungus</i>	<i>chirurgorum</i>	German Tinder or Amadou
"	<i>Laricis</i>	Larch Polyporus
"	<i>Sambuci</i>	Jews' Ears
<i>Galbanum</i>		Gum Galbanum
<i>Gallae</i>		Oakgalls
<i>Gambir</i>		Gambier or Terra japonica
<i>Gemmae populi</i>		Poplar Buds
<i>Glandulae Rotlerae</i>		Kamala
"	<i>Lupuli</i>	Hop-glands; Lupulinum
<i>Gossypium</i>		Cotton wool
<i>Guarana</i>		Guarana
<i>Gummi arabicum</i>		Gum arabic
<i>Gutta percha</i>		Gutta Percha
<i>Gutti</i>		Gamboge
<i>Helminthochorton</i>		Corsican Moss
<i>Herba Absinthii</i>		Common Wormwood
"	<i>Cannabis indicae</i>	Indian Hemp
"	<i>Cardui benedicti</i>	Holy Thistle; Blessed Thistle
"	<i>Centaurei minoris</i>	Centaury
"	<i>Chenopodii ambrosioides</i>	Mexican tea
"	<i>Cochleariae</i>	Common Scurvy-grass
"	<i>Conii</i>	Hemlock
"	<i>Galeopsidis</i>	Hempnettle
"	<i>Hyoscyami</i>	Henbane
"	<i>Jaceae</i>	Heartsease; Pansy
"	<i>Lobeliae</i>	Lobelia (Indian Tobacco)

	Latin Name	English Name
<i>Herba</i>	<i>Majoranae</i>	Sweet Marjoram
	" <i>Meliloti</i>	Melilot
	" <i>Millefolii</i>	Yarrow
	" <i>Polygalae</i>	Milkwort
	" <i>Serpylli</i>	Wild Thyme
	" <i>Thymi</i>	Garden Thyme
	" <i>Violae tricoloris</i>	Heartsease; Pansy
<i>Indicum</i>		Indigo
<i>Jujubae</i>		Jujubes
<i>Kamala</i>		Kamala
<i>Lacca</i>		Lac (Shellac)
	" <i>Musci</i>	Litmus
<i>Laminaria</i>		Tangle
<i>Lichen islandicus</i>		Iceland Moss
<i>Lignum Campechianum</i>		Logwood
	" <i>Fernambuci</i>	Brazil wood
	" <i>Guajaci</i>	Lignum vitae
	" <i>Juniperi</i>	Juniper
	" <i>Quassiae</i>	Quassia chips
	" <i>Santalinum</i>	Sandal wood; Red Sanders
	" <i>Sassafras</i>	Sassafras
<i>Lupulinum</i>		Hop glands
<i>Lycopodium</i>		Lycopodium powder
<i>Macis</i>		Mace
<i>Manna</i>		Manna
<i>Mastic</i>		Mastic
<i>Myrrha</i>		Myrrh
<i>Oleum Amygdalarum</i>		Oil of Almonds
	" <i>Cacao</i>	Cacao butter
	" <i>Cocos</i>	Coconut Oil
	" <i>Crotonis</i>	Croton Oil
	" <i>Juglandis</i>	Walnut Oil
	" <i>Lauri</i>	Oil of Laurel
	" <i>Lini</i>	Linseed Oil
	" <i>Nucistae</i>	Oil of Nutmeg or Oil of Mace
	" <i>Olivarum</i>	Olive Oil
	" <i>Papaveris</i>	Poppy Oil
	" <i>Picis</i>	Pine tar Oil
	" <i>Rapae</i>	Colza Oil
	" <i>Ricini</i>	Castor Oil
	" <i>Rusci</i>	Birch-tar
	" <i>Sesami</i>	Sesame Oil or Gingelly Oil
<i>Olibanum</i>		Gum Olibanum or Frankincense
<i>Opium</i>		Opium
<i>Orleana</i>		Arnotto
<i>Pasta Guarana</i>		Guarana
<i>Pix liquida</i>		Tar
<i>Pulpa Tamarindorum</i>		Tamarind pulp
<i>Radix Alcanneae</i>		Alkanet
	" <i>Althaeae</i>	Marsh mallow
	" <i>Angelicae</i>	Angelica
	" <i>Aconitis</i>	Monkshood or Wolfsbane
	" <i>Aristolochiae</i>	Birthwort Oil
	" <i>Artemisiae</i>	Mugwort
	" <i>Bardanae</i>	Burdock
	" <i>Belladonnae</i>	Belladonna
	" <i>Bryoniae</i>	White Bryony
	" <i>Caricis</i>	Sedge; German Sarsaparilla
	" <i>Carlinae</i>	Carlina Thistle
	" <i>Cichorii</i>	Chicory
	" <i>Colchici</i>	Colchicum or Meadow Saffron
	" <i>Colombo</i>	Calumba root

	Latin Name	English Name
<i>Radix</i>	<i>Consolidae</i>	Comfrey
"	<i>Enulae</i>	Elecampane
"	<i>Foeniculi</i>	Fennel
"	<i>Gentianae</i>	Gentian
"	<i>Glycyrrhizae</i>	Liquorice
"	<i>Helenii</i>	Elecampane
"	<i>Ipecacuanhae</i>	Ipecacuanha
"	<i>Jalapae</i>	Jalap
"	<i>Levistici</i>	Lovage
"	<i>Liquiritiae</i>	Liquorice
"	<i>Mei</i>	Spignel
"	<i>Ononidis</i>	Rest harrow
"	<i>Petroselinii</i>	Parsley
"	<i>Pimpinellae</i>	(Small) Burnet Saxifrage
"	<i>Polygalae amarae</i>	(Bitter) Milkwort
"	<i>Pyrethri</i>	Spanish Chamomile (Pyrethrum)
"	<i>Ratanhiae</i>	Ratanhy
"	<i>Rhei</i>	Rhubarb
"	<i>Salep</i>	Salep
"	<i>Saponariae</i>	Soapwort
"	<i>Sarsaparillae</i>	Sarsaparilla
"	<i>Scammoniae</i>	Scammony
"	<i>Senegae</i>	Rattlesnake-root
"	<i>Symphyti</i>	Comfrey
"	<i>Sumbul</i>	Sumbul root
"	<i>Taraxaci</i>	Dandelion
"	<i>Valerianae</i>	Valerian
<i>Resina</i>	<i>Anime</i>	Gum Animi
"	<i>alba</i>	White Rosin
"	<i>Benzoe</i>	Gum Benzoin
"	<i>burgundica</i>	Burgundy Pitch
"	<i>Copal</i>	Copal
"	<i>Dammara</i>	Dammar
"	<i>Elemi</i>	Elemi
"	<i>Guajaci</i>	Guaiacum
"	<i>Laccae</i>	Lac (Shellac)
"	<i>Mastic</i>	Mastic
"	<i>Pini</i>	White Rosin
<i>Rhizoma</i>	<i>Ari</i>	Common Arum or Wake-Robin
"	<i>Aristolochiae</i>	Birthwort
"	<i>Arnicae</i>	Arnica
"	<i>Calami</i>	Sweet Flag
"	<i>Caricis</i>	Sedge
"	<i>Caryophyllatae</i>	Common Avens
"	<i>Chinae</i>	China Root
"	<i>Curcumae</i>	Turmeric
"	<i>Filicis</i>	Male Fern
"	<i>Galangae</i>	Galanga
"	<i>Graminis</i>	Twitch Couch-grass
"	<i>Hellebori viridis</i>	Green Hellebore
"	<i>Hydrastis canadensis</i>	Golden Seal or Yellow Root
"	<i>Imperatoriae</i>	Masterwort
"	<i>Iridis</i>	Orris root
"	<i>Polypodii</i>	Common Polypody
"	<i>Rhei</i>	Rhubarb
"	<i>Serpentariae</i>	Snake root
"	<i>Tormentillae</i>	Tormentil
"	<i>Veratri</i>	White Hellebore
"	<i>Zedoariae</i>	Zedoary
"	<i>Zingiberis</i>	Ginger
<i>Saccharum</i>		Sugar
<i>Sandaraca</i>		Sandarac

Latin Name	English Name
<i>Sanguis Draconis</i>	Dragon's blood
<i>Scammonium</i>	Scammony
<i>Secale cornutum</i>	Ergot
<i>Semen Abri</i>	Crab's Eyes
" <i>Amygdali</i>	Almonds
" <i>Arecae</i>	Areca nuts
" <i>Cacao</i>	Cacao beans
" <i>Cinae</i>	Semen contra
" <i>Colchici</i>	Colchicum; Meadow Saffron
" <i>Crotonis</i>	Croton Seeds or Tilly Seeds
" <i>Cydoniae</i>	Quince Seeds
" <i>Erucae</i>	White Mustard
" <i>Foenugraeci</i>	Fenugreek
" <i>Hyoscyami</i>	Henbane
" <i>Ignatii</i>	St. Ignatius' Beans
" <i>Lini</i>	Linseed
" <i>Myristicae</i>	Nutmegs
" <i>Nigellae</i>	Fennel Flower; Love in a Mist
" <i>Paeoniae</i>	Peony
" <i>Papaveris</i>	Poppy
" <i>Physostigmatis</i>	Ordeal Beans; Calabar Beans
" <i>Psyllii</i>	Clammy Plantain
" <i>Quercus</i>	Acorns
" <i>Ricini</i>	Castor Oil
" <i>Sabadillae</i>	Sabadilla
" <i>Staphisagriae</i>	Stavesacre
" <i>Strophanthi</i>	Strophanthus seeds
" <i>Sinapis albae</i>	White Mustard
" " <i>nigrae</i>	Black Mustard
" <i>Stramonii</i>	Thornapple
" <i>Strychni</i>	Nux vomica
" <i>Tiglii</i>	Croton seeds
" <i>Tonco</i>	Tonka beans
<i>Siliqua dulcis</i>	Algaroba
<i>Stipites Dulcamarae</i>	Woody Nightshade
" <i>Laminariae</i>	Tangle
<i>Styrax liquidus</i>	Storax
<i>Succus Liquiritiae</i>	Liquorice
<i>Summitates Sabinæ</i>	Savin
<i>Tamarindi</i>	Tamarinds
<i>Terebinthina communis</i>	Common Turpentine
" <i>veneta</i>	Venetian Turpentine
<i>Tubera Aconiti</i>	Monkshood
" <i>Ari</i>	Common Arum
" <i>Colchici</i>	Colchicum or Meadow Saffron
" <i>Jalapae</i>	Jalap
" <i>Salep</i>	Salep
<i>Turiones Pini</i>	Pine-shoots
<i>Tragacantha</i>	Gum tragacanth

Table B.

English Name	Latin Name
Acorns	<i>Semen Quercus</i>
Algaroba	<i>Fructus Ceratoniae, Siliqua dulcis</i>
(Allium victoriale)	<i>Bulbus Victorialis longae</i>
Allspice	<i>Fructus Amomi</i>
Alkanet root	<i>Radix Alcanneae</i>
Almonds	<i>Amygdalae, Semen Amygdali</i>
Aloes	<i>Aloe</i>
Amadou	<i>Fungus chirurgorum</i>
Angelica	<i>Radix Angelicae</i>

English Name	Latin Name
Angostura Bark	<i>Cortex Angusturæ</i>
Aniseed	<i>Fructus Anisi</i>
Araroba	<i>Araroba</i>
Areca nut	<i>Semen Arecae</i>
Arnica flowers	<i>Flores Arnicae</i>
Arnica root	<i>Rhizoma Arnicae</i>
Arnotto	<i>Orleana</i>
Arum bulb	<i>Tubera Ari; Rhizoma Ari</i>
Asa foetida	<i>Asa foetida</i>
Balsam of Copaiba	<i>Balsamum Copaivæ</i>
Balsam of Peru	<i>Balsamum peruvianum</i>
Balsam of Tolu	<i>Balsamum tolutanum</i>
Bearberry leaves	<i>Folia Uvae ursi</i>
Belladonna (leaves)	<i>Folia Belladonnae</i>
Belladonna (root)	<i>Radix Belladonnae</i>
Black Alder	<i>Cortex Frangulae</i>
Black Mustard	<i>Semen Sinapis nigrae</i>
Blackthorn flowers	<i>Flores Acaciae</i>
Blessed Thistle	<i>Herba Cardui benedicti</i>
Birchtar	<i>Oleum Rusci</i>
Brazil wood	<i>Lignum Fernambuci</i>
Buchu leaves	<i>Folia Bucco</i>
Buckbean	<i>Folia Menyanthis; Folia Trifolii fibrini</i>
Buckthorn berries	<i>Fructus Rhamni catharticae</i>
Burdock	<i>Radix Bardanae</i>
Burgundy pitch	<i>Resina burgundica</i>
Cacao beans	<i>Semen Cacao</i>
Cacao butter	<i>Oleum Cacao</i>
Calabar beans	<i>Fabae calabaricae; Semen Physostig-</i>
Calumba	<i>Radix Colombo [matis]</i>
Camphor	<i>Camphora</i>
Canada Balsam	<i>Balsamum canadense</i>
Canella Bark	<i>Canella alba; Cortex Canellae albae</i>
Capsicum	<i>Fructus Capsici</i>
Cardamoms	<i>Fructus Cardamomi</i>
Carline Thistle	<i>Radix Carlinae</i>
Carrageen	<i>Carrageen; Lichen islandicus</i>
Carraway	<i>Fructus Carvi</i>
Cascara Sagrada	<i>Cascara Sagrada; Cortex Rhamni</i>
Cascarilla bark	<i>Cortex Cascarillae [Purshiani]</i>
Castor Oil	<i>Oleum Ricini</i>
Castor seeds	<i>Semen Ricini</i>
Catechu	<i>Catechu</i>
Centaury	<i>Herba Centaurii minoris</i>
Chamomile (flowers)	<i>Flores Chamomillae</i>
Cherry laurel	<i>Folia Laurocerasi</i>
Chicory	<i>Radix Cichoriae</i>
China root	<i>Rhizoma Chinæ</i>
Cinnamom	<i>Cortex Cinnamomi</i>
Clammy Plantain	<i>Semen Psyllii</i>
Cloves	<i>Caryophylli</i>
Crab's eyes	<i>Semen Abri</i>
Croton oil	<i>Oleum Crotonis</i>
Croton seed	<i>Semen Crotonis; Semen Tiglii</i>
Coca leaves	<i>Folia Coca</i>
Cocculus indicus	<i>Fructus Cocculi</i>
Coconut oil	<i>Oleum Cocos</i>
Colchicum (bulb)	<i>Tubera Colchici; Radix Colchici</i>
Colchicum (seeds)	<i>Semen Colchici</i>
Colocynth	<i>Colocynthisides; Fructus Colocynthisidis</i>
Coltsfoot	<i>Folia Farfarae</i>
Colza Oil	<i>Oleum Rapae</i>

English Name	Latin Name
Comfrey	<i>Radix Consolidae</i> ; <i>Radix Symphyti</i>
Common Avena	<i>Rhizoma Caryophyllatae</i>
Common Balm	<i>Folia Melissa</i>
Common Polypody	<i>Rhizoma Polypodii</i>
Common Turpentine	<i>Terebinthina communis</i>
Common Wormwood	<i>Herba Absinthii</i>
Condurango bark	<i>Cortex Condurango</i>
Copal	<i>Copal</i> ; <i>Resina Copal</i>
Coriander	<i>Fructus Coriandri</i>
Corsican Moss	<i>Helminthochorton</i>
Corydalis	<i>Radix Aristolochiae</i> ; <i>Rhizoma Aristolochiae</i> .
Coto bark	<i>Cortex Coto</i>
Cottonwool	<i>Gossypium</i>
Cubebs	<i>Cubebae</i>
Cumin	<i>Fructus Cumini</i>
Curare	<i>Curare</i>
Dammar	<i>Dammar</i> ; <i>Resina Dammar</i>
Dandelion	<i>Radix Taraxaci</i>
Dill	<i>Fructus Anethi</i>
Dragon's Blood	<i>Sanguis Draconis</i>
Elecampane	<i>Radix Enulae</i> ; <i>Radix Helenii</i>
Elemi	<i>Elemi</i> ; <i>Resina Elemi</i>
Elder berries	<i>Fructus Sambuci</i>
Elderflowers	<i>Flores Sambuci</i>
Elm bark	<i>Cortex Ulmi</i>
Ergot	<i>Secale cornutum</i>
Euphorbium	<i>Euphorbium</i>
Fennel (seeds)	<i>Fructus Foeniculi</i>
Fennel seed, Love in a mist	<i>Semen Nigellae</i>
Fennel (root)	<i>Radix Foeniculi</i>
Fenugreek	<i>Semen Foenugraeci</i>
Flowers of Cassia	<i>Flores Cassiae</i>
Foxglove	<i>Folia Digitalis</i>
Galanga	<i>Rhizoma Galangae</i>
Galbanum	<i>Galbanum</i>
Galls	<i>Gallae</i>
Gambier	<i>Gambir</i>
Gamboge	<i>Gutti</i>
Carden Thyme	<i>Herba Thymi</i>
Garlic	<i>Bulbus Allii</i>
Gentian	<i>Radix Gentianae</i>
Ginger	<i>Rhizoma Zingiberis</i>
Golden Seal	<i>Rhizoma Hydrastis canadensis</i>
Green Hellebore	<i>Rhizoma Hellebori viridis</i>
Guaiacum (gum)	<i>Resina Guajaci</i>
Guarana	<i>Guarana</i> ; <i>Pasta Guarana</i>
Guaiacum bark	<i>Cortex Guajaci</i>
Gum Ammoniacum	<i>Ammoniacum</i>
Gum Animi	<i>Anime</i> ; <i>Resina Anime</i>
Gum arabic	<i>Gummi arabicum</i>
Gum Benzoin	<i>Benzoe</i> ; <i>Resina Benzoe</i>
Gum Tragacanth	<i>Tragacantha</i>
Guttapercha	<i>Gutta percha</i>
Hart's truffles	<i>Boletus cervinus</i>
Hemlock (herb)	<i>Herba Conii</i>
Hemlock (seeds)	<i>Fructus Conii</i>
Hempnettle	<i>Herba Galeopsidis</i>
Hempseed	<i>Fructus Cannabis</i>
Henbane (herb)	<i>Herba Hyoscyami</i>
Henbane (leaves)	<i>Folia Hyoscyami</i>
Henbane (seeds)	<i>Semen Hyoscyami</i>
Hollyhock (flowers)	<i>Flores Malvae arboreae</i>

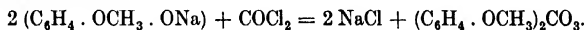
English Name	Latin Name
Hop glands	<i>Lupulinum</i> ; <i>Glandulae Lupuli</i>
Indian Hemp	<i>Herba Cannabis indicae</i>
Indigo	<i>Indicum</i>
Ipecacuanha	<i>Radix Ipecacuanhae</i>
Issue peas	<i>Fructus Aurantii immaturi</i>
Jaborandi	<i>Folia Jaborandi</i>
Jalap	<i>Radix Jalapae</i> ; <i>Tubera Jalapae</i>
Jews' Ears	<i>Fungus Sambuci</i>
Jujubes	<i>Jujubae</i> ; <i>Fructus Jujubae</i>
Juniper berries	<i>Fructus Juniperi</i>
Juniper wood	<i>Lignum Juniperi</i>
Kamala	<i>Kamala</i> ; <i>Glandulae Rottlerae</i>
Kousso flowers	<i>Flores Koso</i>
Lac	<i>Lacca</i> ; <i>Resina Laccae</i>
Larch Polyporus	<i>Agaricus</i> ; <i>Fungus Laricis</i>
Laurel berries	<i>Fructus Lauri</i>
Laurel leaves	<i>Folia Lauri</i>
Laurel oil	<i>Oleum Lauri</i>
Lavender	<i>Flores Lavandulae</i>
Lemon peel	<i>Cortex Citri fructus</i>
Lignum vitae	<i>Lignum Guajaci</i>
Liquorice	<i>Succus Liquiritiae</i>
Liquorice	<i>Radix Glycyrrhizae</i>
Linden flowers	<i>Flores Tiliac</i>
Linseed	<i>Semen Lini</i>
Linseed oil	<i>Oleum Lini</i>
Litmus	<i>Lacca Musci</i>
Lobelia	<i>Herba Lobeliae</i>
Logwood	<i>Lignum Campechianum</i>
Lovage	<i>Radix Levistici</i>
Lycopodium	<i>Lycopodium</i>
Mace	<i>Macis</i>
Male Fern	<i>Rhizoma Filicis</i>
Mallow (flowers)	<i>Flores Malvae</i>
Mallow (leaves)	<i>Folia Malvae</i>
Manna	<i>Manna</i>
Marshmallow (leaves)	<i>Folia Althaeae</i>
Marshmallow (root)	<i>Radix Althaeae</i>
Masterwort	<i>Rhizoma Imperatoriae</i>
Mastic	<i>Mastix</i> ; <i>Resina Mastix</i>
Matico	<i>Folia Matico</i>
Melilot	<i>Herba Meliloti</i>
Mexican tea	<i>Herba Chenopodii ambrosioides</i>
Mezereon bark	<i>Cortex Mezerei</i>
Milkwort	<i>Herba Polygalae</i> ; <i>Radix Polygalae</i>
Mint	<i>Folia Menthae crispae</i> [amaræ]
Monkshood (roots)	<i>Tubera Aconiti</i> ; <i>Radix Aconiti</i>
Mother cloves	<i>Anthophylli</i>
Mugwort	<i>Radix Artemisiae</i>
Mullein	<i>Flores Verbasci</i>
Myrrh	<i>Myrrha</i>
Nutmegs	<i>Semen Myristicae</i>
Nux vomica	<i>Semen Strychni</i>
Oak bark	<i>Cortex Quercus</i>
Oil of Almonds	<i>Oleum Amygdalarum</i>
Oil of Bitter Almonds	<i>Oleum Amygdalarum amarum</i>
Oil of Nutmeg	<i>Oleum Nucistae</i>
Olibanum, Frankincense	<i>Olibanum</i>
Olive Oil	<i>Oleum Olivarum</i>
Opium	<i>Opium</i>
Orange flowers	<i>Flores Aurantii</i> ; <i>Flores Naphae</i>
Orange leaves	<i>Folia Aurantii</i>

English Name	Latin Name
Orange peel	<i>Cortex Aurantii fructus</i>
Orris root	<i>Rhizoma Iridis</i>
Pansy	<i>Herba Violae tricoloris; Herba Jaceae</i>
Parsely (root)	<i>Radix Petrosilini</i>
Parsley (seed)	<i>Fructus Petrosilini</i>
Peony	<i>Semen Paeoniae</i>
Pepper	<i>Fructus Piperis</i>
Peppermint	<i>Folia Menthae piperitae</i>
Pine needle oil	<i>Oleum Picis</i>
Pine shoots	<i>Turiones Pini</i>
Pomegranate bark	<i>Cortex Granati</i>
Pomegranate rootbark	<i>Cortex Granati radices</i>
Poplar buds	<i>Gemmae populi</i>
Poppy heads	<i>Fructus Papaveris</i>
Poppy oil	<i>Oleum Papaveris</i>
Poppy petals	<i>Flores Rhoeados</i>
Poppy seed	<i>Semen Papaveris</i>
Purging Cassia	<i>Cassia fistula; Fructus Cassiae fistulae</i>
Quassia chips	<i>Lignum Quassiae</i>
Quassia bark	<i>Cortex Quassiae</i>
Quebracho bark	<i>Cortex Quebracho</i>
Quince seeds	<i>Semen Cydoniae</i>
Ratanhy	<i>Radix Ratanhiae</i>
Rattlesnake root	<i>Radix Senegae</i>
Rest harrow	<i>Radix Ononidis</i>
Rhubarb	<i>Radix Rhei; Rhizoma Rhei</i>
Roman Chamomile (flowers)	<i>Flores Chamomillae romanae</i>
Rosemary	<i>Folia Rosmarini</i>
Rose petals	<i>Flores Rosae</i>
Rosin	<i>Resina Pini; Colophonium</i>
Sabadilla	<i>Semen Sabadillae; Fructus Sabadillae</i>
Saffron	<i>Crocus</i>
Sage	<i>Folia Salviae</i>
Salap	<i>Tubera Salep; Radix Salep</i>
Sandal wood	<i>Lignum Santalinum</i>
Sandarach	<i>Sandaraca</i>
Sarsaparilla	<i>Radix Sarsaparillae</i>
Sassafras bark	<i>Cortex Sassafras</i>
Sassafras wood	<i>Lignum Sassafras</i>
Savin	<i>Summitates Sabiniae</i>
Sedge	<i>Radix Caricis; Rhizoma Caricis</i>
Scammony	<i>Scammonium; Radix Scammoniae</i>
Scurvygrass	<i>Herba Cochleariae</i>
Semen contra	<i>Flores Cinae; Semen Cinae</i>
Senna	<i>Folia Sennae</i>
Sesame Oil	<i>Oleum Sesami</i>
(Silybum Mariarum)	<i>Fructus Silybi</i>
Simaruba bark	<i>Cortex Simarubae</i>
Small Burnet Saxifrage	<i>Radix Pimpinellae</i>
Snake root	<i>Rhizoma Serpentinae</i>
Soaptree	<i>Cortex Quillajae</i>
Soapwort	<i>Radix Saponariae</i>
Spanish Chamomile	<i>Radix Pyrethri</i>
Spanish Chamomile (flowers)	<i>Flores Pyrethri</i>
Spignel	<i>Radix Mei</i>
Squill	<i>Bulbus Scillae</i>
Star anise	<i>Fructus Anisi stellati</i>
Starch	<i>Amylum</i>
Stavesacre	<i>Semen Staphisagriae</i>
Storax	<i>Styrax liquidus</i>
Strophanthus seeds	<i>Semen Strophanthi</i>
St. Ignatius beans	<i>Fabae St. Ignatii; Semen Ignatii</i>

English Name	Latin Name
Sugar	<i>Saccharum</i>
Sumbul root	<i>Radix Sumbul</i>
Sweet Flag	<i>Rhizoma Calami</i>
Sweet Marjoram	<i>Herba Majoranae</i>
Tamarinds	<i>Tamarindi</i> ;
Tamarind pulp	<i>Pulpa Tamarindorum</i>
Tangle	<i>Laminaria</i> ; <i>Stipites Laminariae</i>
Tar	<i>Pix liquida</i>
Peruvian Bark	<i>Cortex Chinae</i>
Thornapple (leaves)	<i>Folia Daturae</i> ; <i>Folia Stramonii</i>
Thornapple (seeds)	<i>Semen Stramonii</i>
Thyme	<i>Herba Serpylli</i>
Tobacco leaves	<i>Folia Nicotianae</i>
Tonka beans	<i>Fabae Tonco</i> ; <i>Semen Tonco</i>
Tormentil	<i>Rhizoma Tormentillae</i>
Turmeric	<i>Curcuma</i> ; <i>Rhizoma Curcumae</i>
Twitch or Couchgrass	<i>Rhizoma Graminis</i>
Valerian	<i>Radix Valerianae</i>
Vanilla	<i>Fructus Vanilla</i>
Venetian Turpentine	<i>Terebinthina veneta</i>
Walnut leaves	<i>Folia Juglandis</i>
Walnut Oil	<i>Oleum Juglandis</i>
Water Fennel	<i>Fructus Phellandrii</i>
White Bryony	<i>Radix Bryoniae</i>
White Hellebore	<i>Rhizoma Veratri</i>
White Mustard	<i>Semen Erucae</i> ; <i>Semen Sinapis albae</i>
White Rosin	<i>Resina alba</i>
Whortle berries	<i>Fructus Myrtilli</i>
Willow bark	<i>Cortex Salicis</i>
Winter's Bark	<i>Cortex Winteranus</i>
Woody Nighthade	<i>Stipites Dulcamarae</i>
Yarrow	<i>Herba Millefolii</i> ; <i>Folia Millefolii</i>
Zedoary	<i>Rhizoma Zedoariae</i>

Dulcine (SUCRENE, SUCROL) see "SWEETENING MATTERS, ARTIFICIAL".

Duotal = guaiacol carbonate $(C_6H_4 \cdot O \cdot CH_3)_2CO_3$. Two molecules guaiacol (q. v.) are dissolved in caustic soda and one molecule phosgene gas (carbonyl chloride) $COCl_2$ passed into the solution. The action is represented by the following equation:—



A white, nearly tasteless and odourless powder of crystalline structure, insoluble in H_2O , slightly soluble in cold, readily in hot alcohol, in ether chloroform and benzene. M. P. 78—84°.

It is used in medicine as a remedy for tuberculosis, typhus, diarrhoea, &c.

Drying.

Desiccators. Drying ovens, Drying pans &c.:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Drying Apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Emil Passburg, 30 Great Great, St. Helen's, London E.C.

G. Scott & Son Ltd., 2 Talbot Court, London E.C.

Vacuum Drying Cupboard of cast-iron and wrought iron:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Dyeing. See articles on "COTTON DYEING", "WOOL DYEING", "SILK DYEING", "VATS AND VAT DYEING", "TURKEY-ED DYEING". For *fastness* of dyes see "FASTNESS OF DYES".

Dyes, Machines:

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Dyewood-Extract-apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Dynamite. By the name dynamite is understood every blasting powder of which the active principle is mainly nitroglycerine, absorbed by any suitable substance. A distinction is made between dynamites with active and inactive additions. In the latter case the materials possess qualities which also characterize them as blasting and explosive materials.

1. DYNAMITES WITH INACTIVE ADDITIONS.

This class includes KIESELGUHR DYNAMITE, CARBODYNAMITE, RHEXITE, DUALINE, CARBONITE, VIGORITE, VONGES DYNAMITE, HERCULES POWDER, LITHOFRACTEUR, &c.

The most important dynamite is kieselguhr-dynamite (Gurdynamite), that dynamite which is usually called simply dynamite. It usually consists of 45 % nitroglycerine, 24.5 % kieselguhr and 0.5 % soda. The kieselguhr (infusorial earth) employed must be very pure; it is first gently ignited and then more strongly (on being heated too strongly it loses its absorptive powers). It is then ground to a very fine powder and must be used straight away as otherwise it absorbs moisture. The mixing of nitroglycerine with kieselguhr is usually not performed mechanically but by hand. The mixture is repeatedly pressed through metal sieves in order to ensure more complete mixing. The finished dynamite is stamped out in presses in sausage-shaped masses which, wrapped in parchment paper, are brought into commerce as dynamite cartridges.

Gurdynamite forms a doughy, somewhat fatty, odourless mass of brownish-yellow to red colour. When ignited it burns quietly and only explodes when in a confined space. It can be exploded by sudden heating or by a sudden shock. Dynamite solidifies at $+8^{\circ}$ and must then be carefully warmed before using.

Other dynamites with inactive additions are prepared in approximately similar manner. Care must always be taken that the absorbing agents are pure and dry. Among the explosives of this class may be mentioned:

CARBODYNAMITE, containing 90 % nitroglycerine and 70 % cork charcoal.

RHEXITE, 64 % nitroglycerine, 18 % soda saltpetre, 7 % wood meal and 11 % vegetable mould.

DUALIN, 80 % nitroglycerine, 10 % saw-dust, and 10 % nitre.

CARBONITE, 25 % nitroglycerine, 40.5 % wood meal, 34 % sodium nitrate, and 0.5 % Na_2CO_3 .

VIGORITE, 30 % nitroglycerine, 9 % wood stuff, 5 % magnesium carbonate, 49 % potassium chlorate, and 7 % potassium nitrate.

VONGES DYNAMITE, 75 % nitroglycerine, 20.8 % randanite (decomposed felspar), 3.8 % quartz and 0.4 % magnesium carbonate.

HERCULES POWDER, 40 % nitroglycerine, 12 % wood stuff, 46 % sodium nitrate, 1 % common salt and 1 % magnesium carbonate.

LITHOFRACTEUR, 54 % nitroglycerine, 15 % barium nitrate, 17 % kieselguhr, 2 % wood meal, 1 % bran, 4 % sulphur, 2 % manganese dioxide, and 2 % sodium carbonate.

WITTENBURG WEATHER DYNAMITE, 25 % nitroglycerine, 34 % potassium nitrate, 38.5 % rye meal, 1 % wood-meal, 1 % barium nitrate, 0.5 % sodium bicarbonate.

Many other mixtures have been proposed but have not attained any practical importance. It can also be seen that several of these explosives contain besides nitroglycerine other substances which increase the explosive power so that they can also be included in the second class; but such additions are for the greater part only of a secondary nature, and the real absorbent, or the larger part of it is active (see SAFETY EXPLOSIVES).

2. DYNAMITES WITH ACTIVE ABSORBENTS.

The principal members of this class are blasting gelatine and gelatine dynamite, meganite; colonia powder may also be mentioned.

With blasting gelatine and gelatine dynamite the absorbent is collodion wool (dinitrocellulose) (see COLLODION and GUN COTTON). Dinitrocellulose dissolves in nitroglycerine; the latter is heated in copper pans to 50–60° and the carefully dried collodion wool introduced. If other substances are to be added the mixture is worked in suitable kneading machines. In many instances the mixing is carried out by hand even though this method is becoming less general on account of the great danger.

The blasting gelatines contain 92 % nitroglycerine and 8 % dinitrocellulose; and very often nitre. It forms a horn-like, transparent mass which can be cut and moulded and is more powerful as a blasting agent than dynamite, but soon loses part of its strength when stored, on account of its giving off nitroglycerine. The latter quality renders blasting gelatine dangerous and has frequently given rise to explosions. It is however less easily exploded by shock than dynamite, and special igniting cartridges are necessary to bring about its explosion. Blasting gelatine in the frozen state is very unstable and dangerous. On account of the numerous dangers attached to its use blasting gelatine has not been a complete commercial success. It is used under water, where the common form of dynamite cannot be employed. For mixing the constituents of blasting gelatine special mixing machines are in use, since the mass must be heated during the treatment and is then very sensitive to mechanical shock.

Recently the attentions of inventors have been again directed to blasting gelatine. According to the English Pat. 18161 (1901) one part of nitrotoluene and 2 parts of nitroglycerine are mixed and 5 parts of insoluble gun cotton added; then 2 parts of acetone are added and the whole granulated. The English Pat. 23846 (1902) manufactures blasting gelatine, not from nitroglycerine and collodion wool, but by mixing nitroglycerine with a solution of glue in glycerine. The Germ. Pat. 144846 is peculiar. According to this, acetylene is absorbed by acetone and this (explosive) solution is employed for gelatinizing nitroglycerine and nitrocellulose. It must be surmised that, after the evaporation of the acetone, all the acetylene escapes.

Gelatine dynamite is made from the so-called "gelatine" and the mixing powder. This "gelatine" is a mixture of nitroglycerine and dinitrocellulose, while the mixing powder is a mixture of sodium nitrate, wood meal, and sodium carbonate.

Three gelatine dynamites had the following composition:

	I	II	III
Nitroglycerine	62.50 %	43.60 %	63.50 %
Dinitrocellulose	2.50 %	1.80 %	1.50 %
Sodium nitrate	26.25 %	41.10 %	27.00 %
Wood meal	8.40 %	13.15 %	8.00 %
Sodium carbonate	0.35 %	0.35 %	—

The manufacture is carried out as in the case of blasting gelatine, the mixing being done by hand. Gelatine dynamite is gradually replacing blasting

gelatine and also the ordinary dynamite. A very powerful variety of dynamite (extra dynamite) is obtained by adding ammonium nitrate to the mixture.

Meganite consists of nitroglycerine and dinitrocellulose to which is added a nitro mixture to ensure complete combustion. In order to prepare it the nitro mixture and the dinitrocellulose are mixed by hand with the nitroglycerine and the whole passed through a brass sieve. In this way the danger of heating is avoided and a more uniform product is obtained. Meganite becomes neither hard nor gelatinous, only freezes with difficulty and explodes like dynamite.

Colonia powder is a mixture of 30—35 % nitroglycerine with 65—70 % of ordinary gun powder.

See also "SAFETY EXPLOSIVES".

Dynamite:

Sprengstoff A.-G. Carbonit, Hamburg.
Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin.

Apparatus for Dynamite:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Dynamos:

Cannings, Great Hampton St., Birmingham.

E.

Earth see "SOILS".

Earthenware (CROCKERY). By this term are meant clay wares of porous structure, which are glazed. The following varieties can be distinguished, 1. fine fayence or crockery, 2. common fayence or majolica, and 3. potter's wares.

The different varieties can be distinguished from one another by the kind of glaze. The real crockery (English earthenware) or the fine fayence has transparent glazes which are either colourless, so that the painting underneath can be readily seen, or are coloured, so that the earthenware shines through.

On the other hand the glazes of majolica are rendered non-transparent (by means of SnO_2) and are either white or coloured; the design is brought on to the glaze and melted together with the latter during the burning. Crockery, when broken, forms white hard ringing fragments, while those of the common fayence are burnt at a low temperature from yellowish-red clay frequently with the addition of chalk, and may readily be scratched.

For the manufacture of crockery "fatty" pliable clays (plastic clays) which burn white are used with the addition of quartz or finely ground flint stone. The composition of the mass varies, the percentage of clay substance lies between 35 and 65 %, that of quartz between 35 and 60 %. The glazes, which are burnt on at a temperature very much lower than that at which the articles are burnt, are either lead alkali silicates or are boric acid glazes free from lead.

As raw material for majolica the calcareous diluvial clays are used (just as for bricks); the clay is then freed from the larger stones by suspension in water and mixed with the requisite amount of chalk — sometimes with the addition of fine yellow sand (in case of very "fatty" clays). The majolica masses contain usually between 25 and 40 % CaCO_3 . The glazes of majolica are lead silicates, which are made non-transparent by the addition of tin oxide SnO_2 .

With regard to the composition of coloured glazes compare the article on "PORCELAIN COLOURS". The painting of the glazes on majolica is also carried out with the latter; the addition of white tin glaze raises the melting point of the porcelain colours.

Earthenware:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Earthenware goods. By this name are understood clay wares of dense structure which are very similar to porcelain. Earthenware however is non-transparent or only to a very slight extent transparent, and is white in the finest classes, but otherwise coloured, slate blue, gray or brown; earthenware is usually glazed. The clays used for its preparation are very plastic, comparatively fire proof, and contain a varying amount of iron. They usually contain so much felspar, quartz and alkali silicate that they can be worked for earthenware articles without any further addition of fluxes, provided the clays are not altogether too fatty; in the latter case quartz, unglazed, burnt and then ground earthenware fragments are mixed with the mass. The glazing of the earthenware articles is carried out either in the raw state by pouring the glaze over the articles, in which case glazes of calcareous clay, potash felspar with chalk, kaolin and quartz, boric acid glazes, or lead glazes are used, or, instead of pouring a glaze on the finished articles, ordinary salt is thrown into the furnace. The water vapour in the flames reacts with the salt with the formation of HCl and NaOH; the latter unites with the aluminium silicates which are just beginning to soften and forms on the surface of the articles a readily fusible sodium aluminium silicate which covers the pieces with a glistening skin. The burning of the earthenware goods, which, like that of the porcelain wares, is carried out either in crucibles or in such a way that the objects are protected from flying ashes by walls of bricks, requires a rather high temperature, especially when the glaze is to be made in the way just described by throwing salt into the furnace.

With regard to the use of corundum for the manufacture of earthenware vessels for chemical purposes compare the articles "CORUBIN" and "CORUNDUM".

Earthenware-Cups:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Earthenware-Preparations:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Earthenware-Transport vessels:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).
Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Earthnut cake see FEEDING STUFFS.

Earthnut oil. An oil obtained from the fruit of the earthnut (*Arachis hypogaea*). The shells are removed and the fruits pressed, first cold and then hot. The seeds contain from 38—50 % of oil.

Colourless or yellow mobile oil S. G. (at 15°) 0.199. At 0° it becomes semi-solid. The oil is used for the preparation of soap, to adulterate olive oil, as a lubricant and (the cold pressed oil) for culinary purposes.

Earth pitch see ASPHALT.**Earthy talc** (MAGNESIUM OXIDE) see under "MAGNESIUM COMPOUNDS".**Earth wax** see OZOKERITE.**Eau de Javelle** see BLEACHING.**Ebonite** see CAOUTCHOUC.**Ecgonine** see COCAINE.**Edge Rollers.****Edge Rollers:**

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Edinol see PHOTOGRAPHIC CHEMICALS.

Egg Yolk.

Egg yolk:

W. Eug. Seemann, Stuttgart, Germany.

Eikonogen see "PHOTOGRAPHIC CHEMICALS".

Ektogan. A preparation of ZnO containing 40—60 % zinc peroxide. It is odourless and non-poisonous. Used as a dressing for wounds, burns, in operations and for skin disease. It also serves as an astyptic.

Elaic acid see "OLEIC ACID".

Electric lighting see the articles NERNST LAMPS, OSMIUM LAMPS, TANTALUM LAMPS, ZIRCONIUM LAMPS, MERCURY VAPOUR LAMPS, MOLYBDENUM LAMPS and TUNGSTEN LAMPS.

Electrical units.

1. Current strength or current intensity. Unit is the ampère (amp.).

The unit of the electric current strength is defined as the unalterable electric current, which, in passing through an aqueous solution of silver nitrate, deposits 0.001118 grm Ag in one second. This unit is the ampère.

2. Resistance. Unit is the ohm (Ω).

This unit of measurement is the resistance offered to the electric current by a column of mercury, one sq. millimetre in section, and 106.3 cm long, at 0° C., the mass of the same being 14.4521. This unit of resistance is the ohm.

3. Electromotive force. Unit is the volt (V).

The unit of electromotive force is that force which produces a current of one ampère in a conductor with a resistance of one ohm. The unit is called the volt.

4. Unit of quantity is the coulomb (coul.).

The unit of quantity is defined as the amount of current which passes in one second, through a conductor having a resistance of 1 ohm, acting through a difference of potential of 1 volt; or the amount produced by 1 ampère in 1 second. This amount of electricity is the coulomb.

5. Power. Unit is the watt (W).

This unit is defined as the work done in one second by a current of one ampère acting through a difference of potential of 1 volt. This power is the watt.

The above mentioned electric units may be reduced to the absolute measurement system "the C. G. S. system". In practice the SIEMENS unit of resistance is often taken for measuring resistances. It is the resistance of a column of mercury of section 1 sqmm and 1 m length, at 0°.

1 ohm = 1.06 S. units. 1 S. U. = 0.944 ohms.

In measuring the difference of potential the EMF. of a DANIELL'S CELL (D) is often taken as the standard.

1 volt = 0.90 D; 1 D = 1.12 volt.

The amount of electricity which flows through a circuit, the current strength being 1 amp., in one hour is called the ampère hour. It is therefore 3600 coulombs.

Compare also the article "ELECTROCHEMICAL SIGNS".

Electric boiling apparatus has in recent years been very much used in laboratories on account of its great convenience and cleanliness. The results are very satisfactory. When it is considered that an ordinary fire hardly yields 7 % of the total heating value of the coal, it becomes apparent that the electric boiling apparatus can under certain conditions compete with the coal fire even with regard to cost.

The principle of most of the electric boiling apparatus is as follows. The part of the vessel to be heated carries a band of metal which has burned on to it, an insulating layer of enamel. As the enamel layer forms the outside of the vessel very little heat is lost, especially as a second exterior vessel is provided, forming an air-jacket which prevents loss of heat by radiation. Other constructions make use of heating wires of nickel or nickel alloys. To prevent oxidation the wires are surrounded by an enamel mass, or glass beads are placed on them with the same object. In other cases platinum wires are wound on to a thread of asbestos and then embedded in clay. Different degrees of heat are obtained by arranging several heating systems parallel to one another.

In the widely used electric boiling apparatus "Prometheus", metals in wide strips are fused into an isolating layer of enamel or mica.

The Allgemeine Elektrizitätsgesellschaft in their boiling and heating apparatus use heating materials which are prepared in four different forms — according as higher or lower temperatures are required. In the first system the heating wires are embedded in enamel. These heating materials are only for comparatively low temperatures — to about 100° C. In the second class of apparatus the heating wires are laid in symmetrical order in fire proof insulating materials on the sides. In these two systems heating materials of ordinary resistance wires are contained, while in the third class only wires of precious metals are used, which are fastened by means of an adhesive mass to a metal frame. In the fourth class the electric arc is used as a source of heat.

The electric boiling and heating apparatus of the Kryptol Company is based upon an entirely new principle. Heating wires or bands &c., which are connected rigidly with the boiling vessel, are not used, but instead, a loosely-lying granulated resistance mass. This resistance mass is a mixture of graphite, carborundum and clay, and is known under the name of "Kryptol". (Patents either obtained everywhere, or applied for.) The kryptol is strewn loosely on a non-conducting surface so that a passage for the current is formed between the two poles. The granulated structure of the kryptol causes the current to meet resistance on passing through the mass, and so great heat is developed. It is also advantageous because the loose layer of kryptol adapts itself to the shape of the vessels placed on it (the vessels must of course be non-conductors). The simplest form is arranged in such a way that the under layer consists of a fireclay or enamelled iron plate on either side of which, right and left, an electrode of gas carbon is placed. The space between both electrodes is filled with a loose layer of dry kryptol strewn over the plate. When the current is turned on the kryptol begins to glow within a few minutes, and develops such heat that temperatures up to 2500° may be obtained. The heat can be regulated to any extent not only by altering the strength of the current, but also by varying the thickness of the layer of kryptol, by altering the distance between the electrodes, &c. &c.

Electric carbons. The different kinds of charcoal intended for the manufacture of electric carbons are reduced to the necessary fineness, mixed with a binding material so as to bring the mass into the required form, and then strongly heated in the absence of air. In this way carbons of varying density and porosity can be prepared. The temperature in the furnace must be so adjusted that the entire mass is "coked". For the raw materials the different kinds of charcoal must be in as pure a state as possible. Part of the gas only is removed. Among other suitable materials may be mentioned the gas carbon from the retorts of gas-works, coke of different origin, anthracite, coal that has been well heated, soot, different kinds of graphite, charcoal, &c. &c. The essential condition is that the materials must be pure, and as free as possible from ash. For many purposes the retort carbon — gas carbon — is most

suitable, but the price is too high to allow of its being used alone. It is therefore crushed, mixed with cheaper sorts of charcoal, and then powdered graphite is added to increase the conductivity. The so-called "effect carbon" contains in addition calcium, silicon, and magnesium compounds. — 20 to 25 % of such substances are usually added to the retort charcoal; calcium fluoride is the material most commonly used.

With regard to the carbons for electrolysis, the chief raw material is wood charcoal because this is very resistant to the action of acids; anthracite, smelting coal, tar graphite, oils, tar and other organic substances are also used.

If specially porous electric carbon is required then wood powder or salts (e. g. sal-ammoniac) are added to the mass. The formation of coke or the development of gas causes the mass to be porous.

Electrical conductivity.

Electrical conductivity of the metals ¹⁾ (taking mercury at 0° C. as standard = 1).

	Temp. Cent.	Con- ductivity.		Temp. Cent.	Con- ductivity.
Aluminium	0°	31.726	Lead	—	4.99
"	100°	16.15	Lithium	20°	10.69
Antimony	18.7°	2.413	Magnesium	17°	14.33
Arsonic	0°	2.679	Mercury	0°	1
"	100°	1.873	Nickel	0°	7.374
Bismuth	0°	0.8002	Palladium	17.2°	7.11
Calcium	16.8°	12.46	Platinum	0°	5.615
Cadmium	0°	13.96	"	"	8.257
Cobalt	0°	9.685	Potassium	20°	10.69
Copper	0°	45.74	Silver	0°	56.252
"	18°	53.87	Sodium	20°	14.06
"	100°	33.82	Steel, heated	0°	8.704
Gold, hard	0°	43.84	" Puddle	15°	6.803
" soft	0°	44.62	" Bessemer	15°	4.060
Indium	0°	11.23	Strontium	20°	3.774
Iron	0°	8.3401	Thallium	0°	5.225
		7.861	Tin	0°	9.346
		9.685	"	100°	6.524
"	100°	6.803	Zinc	0°	16.92

Electrical conductivity of some non-metals (taking silver as standard = 100).

	Temp. Cent.	Con- ductivity.		Temp. Cent.	Con- ductivity.
Carbon:			Phosphorus:		
a) Ceylon-graphite	22°	0.0693	amorphous	20°	0.00000123
b) purified-Germ.	22°	0.00395	Tellurium	19°	0.000777

¹⁾ From V. BUCHKA, "Physikalisch-chemische Tabellen der anorganischen Chemie". Stuttgart 1895.

Electric conductivity of solutions (taking Hg as standard = 10^9 at $18^\circ\text{C}.$).

$K = cp - c^1p^1$, where K = conductivity; p = amount of substance in unit mass of the solution; and c and c^1 = two constants (KOHLRAUSCH).

Substance	c 0.00000	c ¹ 0.000000	Substance	c 0.00000	c ¹ 0.000000
HCl	887	297	Ba(OH) ₂	196	066
LiOH	611	327	NH ₄ Cl	177	011
HNO ₃	534	101	Li ₂ CO ₃	175	708
NaOH	445	153	H ₂ C ₂ O ₄	167	089
H ₂ SO ₄	415	048	KHSO ₄	165	021
HBr	383	060	KCN	165	012
KOH	350	055	LiCl	160	046
HI	250	—	MgCl ₂	150	045

Substance	c 0.00000	c ¹ 0.000000	Substance	c 0.00000	c ¹ 0.000000
NaCl	138	025	Ca(NO ₃) ₂	087	021
CaCl ₂	134	027	BaCl ₂	077	008
KCl	131	004	KHCO ₃	075	010
KF	131	018	K ₂ C ₂ O ₄	071	013
NH ₄ NO ₃	116	012	NH ₄ I	070	— 030
(NH ₄) ₂ SO ₄	112	017	KClO ₃	069	—
K ₂ CO ₃	113	016	NaC ₂ H ₃ O ₂	067	023
Na ₂ CO ₃	103	037	H ₂ PO ₄	064	— 011
SrCl ₂	098	015	KI	063	001
K ₂ C ₂ O ₄	097	011	MgSO ₄	060	021
Li ₂ SO ₄	093	036	NaI	057	003
Mg(NO ₃) ₂	092	020	LiI	057	003
KNO ₃	092	013	H ₂ KPO ₄	052	014
K ₂ SO ₄	091	010	AgNO ₃	051	007
NaNO ₃	090	017	K ₂ Al ₂ (SO ₄) ₄	047	—
Na ₂ SO ₄	089	024	ZnSO ₄	042	012
KBr	087	005	CuSO ₄	041	011

Electrical measuring instruments.

A voltmeter is used for measuring the difference of potential, an ampèremeter for measuring the strength of the current, and a wattmeter for measuring the work performed. For permanent technical plants switch-board instruments are necessary, whereas, in the chemical laboratory, portable measuring instruments are usually chosen. In the latter case electrostatic voltmeters and galvanometers of different kinds, and resistances are used.

Electrochemistry (ELECTROLYSIS). The electric current is used in chemical industry for the preparation of various elements and compounds and also in analytical processes.

In electrochemistry either the electrolytical power of the current or the heating effect (Joule effect) is made use of.

With regard to the conduction of the current, we may distinguish conductors of the first and second order, of which the first are only heated and the second chemically altered (electrolysed) when the current is passed. The conductors

of the second order are termed ELECTROLYTES and the constituent parts of the electrolyte IONS.

As an example of an electrochemical process in aqueous solution we may mention the electrolytical processes for obtaining copper by the SIEMENS-HALSKE and by the HOEPFNER methods. An electrochemical process where the electrolytic power of the current and the Joule heat effect are made use of simultaneously, is HEROULT's process for obtaining aluminium. (Comp. article on ALUMINIUM.)

Other electrochemical processes are mentioned in the articles, "BLEACHING", "CHLORINE", "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL", "CARBIDES", "MAGNESIUM", "SODIUM", "OZONE", "PHOSPHORUS", "OXYGEN", "SILICIDES", "PERSULPHURIC ACID", "WATER PURIFICATION" &c. &c. The prospects of obtaining organic compounds by electrolytic methods are very favourable. This has already been carried out in many cases, e. g. chloral, chloroform, iodoform, naphthazarin, saccharine, prussian blue, aniline black, alizarin, and other tar dyes are obtained electrolytically.

Compare also the article "ELECTROCHEMICAL APPARATUS" and "ELECTROCHEMICAL SIGNS,,."

Electrochemical apparatus. In special articles see "ACCUMULATORS", "DIAPHRAGMS", "ELECTRIC CARBON", "ELECTRIC MEASURING INSTRUMENTS", "ELECTRODES", "ELEMENTS, GALVANIC".

Electro-chemical apparatus:

Cannings, Great Hampton St., Birmingham.

Electrochemical signs. At the International Congress of Applied Chemistry, Berlin 1903, the following letters were agreed upon for denoting the electrochemical measuring units.

1. Variable.

p, P	ordinary and osmotic pressure.
v	volume.
T	absolute temperature.
θ	Celsius temperature.
t	time.
δ	density.
Δ	vapour density, compared with air.
n_c, q_c, s_c	critical magnitudes (pressure, volume, temperature).
π, q, s	reduced state of magnitudes (pressure, volume, temperature).
Q	amount of heat.
U	internal energy.
a	atomic weight (O = 16).
M	molecular weight (O ₂ = 32).
c	specific heat.
c_p, c_v	" " at constant pressure or volume.
$C_p = c_p M$ $C_v = c_v M$	molecular heats at constant pressure or volume.
N	
N	coefficient of refraction.
κ	conductivity in reciprocal ohms per cm-cube.
η	concentration (grm equivalents per cm).
$\Lambda = \frac{\kappa}{\eta}$	equivalent conductivity.
Λ_∞	equivalent conductivity at infinite dilution.
γ	degree of dissociation.
K	constants of equilibrium of law of chemical mass of action.
E	difference of potential.
W	resistance.

- I intensity or strength of current.
 ε single potential, difference of potential of decomposition.
 ε_{H} potential against a normal hydrogen electrode.
 ε_{c} potential against a normal calomel electrode.

2. Constants.

- R Gas constants per l mol.
 A mechanical equivalent of heat 41.98×10^6 erg 15° — grm — cal.
 F charge of valency (96540 coulombs per grm — equivalent).

3. Abbreviations in the text.

- 2n. H_2SO_4 &c. for twice normal sulphuric acid, &c.
 H⁺, Cl⁻, Ba⁺⁺ &c. for single (positively) charged H-ion, singly negatively charged Cl-ion, doubly positively charged Ba-ion, &c.

Electro-deposition (ELECTRO-PLATING). The production of firmly adhering metallic deposits by electrolytical methods. The material to be plated is hung up at the cathode, while the anode consists of a sheet of the metal to be deposited. The electrolyte is generally a solution of the cyanide of the metal in a solution of potassium cyanide. For details see the articles on "GOLD PLATING", "COPPER PLATING", "BRASS PLATING", "NICKEL PLATING", "PLATINUM PLATING", "SILVER PLATING", and "STEEL PLATING".

In electro-plating the most important detail to be observed is the preparation of an absolutely clean metallic surface on the articles to be plated. Therefore a mechanical cleaning by brushing and scraping, and a chemical cleaning by "dipping" (q. v.) has to be carried out before the objects are placed in the electrolyte. Finally follows a treatment intended to remove all grease — rinsing in benzene or petroleum ether, or boiling in a solution of caustic soda or soda; different metals require different treatment.

It has been shown by many investigations that smooth coherent deposits may be obtained by adding to the bath various organic colloids, e. g. albumen, gelatine, gum, starch, &c. Many patents have been granted for this purpose, particularly in the case of copper electroplating.

Recently preparations for electroplating have been introduced which are adapted for cyanide baths. These are the so-called TRIPLE SALTS or TRISALYTES.

They are composed of the cyanide of the metal to be deposited, KCN and K_2SO_3 , are chemically pure, of constant composition, and are well adapted for the processes of metallic colouring. The most important commercially are:—

Copper trisalyte (20 % Cu), Zinc trisalyte (15 % Zn), Silver trisalyte (30 % Ag), and Gold trisalyte (40 % Au), Bronze and brass baths can also be obtained by suitable combinations.

Electrodes. Electric carbons are treated in a special article. A few of the newer processes for manufacturing electrodes may be mentioned here.

The Germ. Pat. 157122 aims at the preparation of electrodes of iron oxide. The process is based on the well known fact that ordinary non-magnetic iron oxide becomes magnetic at the temperature of fusion. According to this patent, the residue from the roasting of pyrites, just as it is, after being freed from Cu, is melted in the electric furnace, and then poured into suitable moulds. Such electrodes are considerably cheaper than those of good magnetic iron ore, and possess a conductivity which is 6.6 times as great as that of the latter. They are also very pure as the impurities are almost completely volatilized in the electric furnace, and are therefore very suitable for the chlorine-alkali electrolysis, and give a much lower difference of potential than platinum electrodes.

According to the Swedish Pat. 18742 (1903) active electrodes may be prepared from iron oxide by heating iron plates in the presence of air to a

white heat, and then dipping them into cold water, by which means the layers of iron oxide which contain carbon break off. This broken mass is dried, powdered, mixed with lead ore and graphite, and finally worked with H_2O into a paste, from which the electrodes are formed.

The Swedish Pat. 19682 (1903) of the same inventor states that oxides which are bad conductors may be rubbed together with graphite, and the electrodes formed from this mass.

According to the Germ. Pat. 163125, a hard porous electrode-mass, insoluble in alkalis, may be made from copper oxide by mixing CuO with a solution of $CuCl_2$ to a thick paste, to which fine copper filings are added. The paste is then heated for half an hour to 100° , the water is volatilized and a solid spongy mass of metallic oxide is left. Such electrodes are said to possess different advantages; they are intended to be used as primary and secondary elements.

Electrolysis see "ELECTROCHEMISTRY".

Electromagnetic ore separator see "SMELTING".

Electrometallurgy see „ELECTROCHEMISTRY“.

Electroplating see "PLATING" and „ELECTRO-DEPOSITION“.

Elementary analysis. After M. DENNSTEDT had published (Chem.-Ztg., Repert. 1897, 179) a simplified process for elementary analysis, in which no combustion furnace was needed, by which C, H, N, S and the halogens could be determined in one operation, he has improved his method (Zeitschr. f. anal. Chem. 1902, 525 and Chem.-Ztg. 1902, Repert. 324) in the following manner: For combustion in a stream of O platinized quartz is used as a contact substance instead of platinum sponge. The former is prepared by heating pieces of quartz (as big as the fist) to a bright red heat and then cooling them in cold water. The quartz thus prepared is broken into pieces as large as peas and laid in a 10 % $PtCl_4$ solution, heated a short time on the water-bath and then evaporated to dryness. The decomposition of the $PtCl_4$ is brought about by heating the impregnated quartz pieces with the blowpipe. The platinized quartz thus obtained, on being heated with a bunsen burner, should continue to glow again in the escaping gas after the flame has been extinguished. 6—8 cm of the combustion tube are filled with this prepared quartz; and also 3 cm of the tube, near the end at which the oxygen enters, are filled with pieces of pure quartz. Although, according to the first account of DENNSTEDT, the halogens may be held back by molecular silver, the latter is now only used when I is present, while in presence of Cl and Br pure PbO_2 suffices for the complete absorption of these halogens as well as for retaining S and N. An important source of error in the estimation of H is the rubber tubing used for connecting the drying towers with vessels containing the air and O, on account of the formation of H_2O . It is therefore recommended to set another $CaCl_2$ tube, which leads directly into the combustion tube, behind the drying towers. Further the rubber corks give off moisture and should therefore be dried before using for the first time. The cork in the fore part of the tube should always be placed in a dessicator after the combustion. The saving by using this method may be judged by seeing that with one glass tube 30—40 N determinations (or even as many as 120 other elementary analyses) can be carried out.

Recently DENNSTEDT has modified his process so that it becomes useful as a very quick method. We cannot however enter here into details but must refer our readers to the original articles of DENNSTEDT in

the Chem.-Ztg. 1905, 52. A further account of the method is given in Chem.-Ztg. 1905, Rep. 390.

It may be mentioned that, according to E. LIPPMANN (Vienna), copper oxide asbestos is in every respect superior to the platinum quartz in carrying out the DENNSTEDT elementary analyses. The method is thus rendered simpler and cheaper, without losing any of its exactness.

Electrotype processes. An electrolytical precipitation of metals in a dense coherent form so as to obtain casts which can be removed from the moulds; electrotype processes must not be confused with ELECTRODEPOSITION (q. v.). The metal is always deposited at the negative electrode (cathode), while the same amount of metal is dissolved at the positive electrode (anode).

For electrotype reproductions copper is almost always used since other metals are not uniformly deposited on objects made to conduct by means of graphite. When electrotype reproductions in other metals are required a thin coating of copper is first given to the mould after treatment with graphite, or a silver film is deposited by purely chemical means and the model then placed in the electrotyping solution.

The moulds are made of guttapercha, plaster of Paris, wax or glue. One of the most used recipes for wax moulds is 900 parts yellow wax, 135 parts Venetian turpentine and 22.5 parts finest graphite powder. For glue moulds which can be taken from casts with fairly deep hollows and narrow openings without injuring the cast a solution of 30 parts best glue in 50 parts H_2O and 15 parts glycerine is recommended. After solidifying the glue matrix is dipped into a tannin solution (1:10) so as to convert the outer portions into insoluble tannate of glue. Easily fusible alloys are also used for making moulds.

With the last exception (metallic forms) the surface of the matrix has to be made electrically conducting. Fine washed graphite is generally used for this purpose; it is mixed into a paste with methylated spirits and applied with a brush; after drying soft brushes are used to produce a smooth polished surface. — When a conducting silver film is required on the matrix, the chemical method is adopted. An alcoholic solution of silver nitrate is applied with a brush and H_2S allowed to act up on it. The resulting silver sulphide is a fairly good conductor. Metallic silver is produced by brushing with a mixture of albumen and common salt and then dipping into a solution of silver nitrate; the silver chloride is reduced by dipping into ferrous sulphate solution. Good results are obtained by treating with silver nitrate and yellow phosphorus; the process is, however, dangerous as the solution of silver nitrate in carbon bisulphide is highly inflammable. The safest method is to dip the articles into a 5 % solution of silver nitrate and then into the phosphorus solution proposed by STEINACH and BUCHNER:— 5 g wax, dissolved in 5 g warm turpentine oil, are added to a mixture of 5 g phosphorus, 1 g guttapercha, 5 g asphalt and 120 g carbon bisulphide; after solution has taken place 4 g collodion wool dissolved in 60 g alcohol and 60 g ether are added, the whole well shaken and the clear liquid separated from the sediment after standing for a day.

Frequently a dry treatment will suffice. The surface is painted with rapidly drying varnish, and brass powder is sprinkled over the moist varnish; when the latter is dry the surface is made smooth with a soft brush dipped into brass powder.

The vats employed are generally of stone ware, but enamelled cast-iron and lead-lined wooden vessels may also be used. The anodes must be of the purest electrolytical copper and the area should be at least equal to the total area of the moulds.

In order to ensure uniformly thick deposition differences of concentration in the liquid must be avoided; with this object stirring contrivances are

provided or air is blown through the vats. All articles before being hung in the liquid must be rinsed with alcohol and then with water so that the solution may touch uniformly at all points.

The composition of the electrolyte varies greatly; solutions of copper sulphate are generally used which contain 1.5—2 parts by volume of concentrated H_2SO_4 to 100 of water. For copper printing plates LANGBEIN recommends a 20 % solution of CuSO_4 with 3 % H_2SO_4 ; current 1.3 ampères.

Elemi. Mixture of different resins derived from the *Burseraceae*. It occurs as a whitish or dark yellow soft balsamy mass which is used principally to prevent varnishes from becoming brittle. It is also used as a fumigating agent, more rarely for the preparation of ointments and plasters. There are several different kinds of elemi of which however the Manilla Elemi is the most common commercial article. Besides this the Brazilian and West Indian (Yucatan) varieties may be mentioned.

Elevators:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk Magdeburg-Buckau, Germany.
Max Friedrich & Co., Leipzig-Plagwitz 17.

Ellagic acid see GALLOGENE.

Emanosal. A preparation containing radium added to baths in order to give them a certain proportion of radium emanation, and so to imitate the curative effect of the natural waters. It is used in cases of baths for rheumatism, gout, &c.

Emetine. Alkaloid of the ipecacuanha root (*Radix Ipecacuanhae*), the root of the *Uraroga Ipecacuanha* (*Cephaelis Ipehacuanha*), a Brazilian plant.

It is an almost colourless alkaloid which turns yellow on long exposure to light, readily soluble in alcohol, chloroform, ether, and benzene, not so readily soluble in boiling petroleum-ether and in water.

M. P. 68° , formula $\text{C}_{15}\text{H}_{22}\text{NO}_2(\text{C}_{30}\text{H}_{40}\text{N}_2\text{O}_6)$. It is considered to be one of the best emetics known.

Empyroform. A condensation-product of birch tar and formaldehyde.

It forms a greyish-brown, fine, almost odourless powder, insoluble in water, soluble in alcohol, ether, acetone, and chloroform.

It is a tar preparation highly valued in medicine. Used externally in the treatment of skin diseases, especially of eczema. In this case it is used as a powder, in the form of ointment or as a paste, to some extent also in the form of tinctures, or as soap (empyroform soaps).

Emser salt, artificial. 90 parts NaCl , 220 parts NaHCO_3 , 2 parts sodium sulphate dry, and 4 parts potassium sulphate.

0.8 grm salt are to be taken in one drinking-glass (200 cc) of spring water.

Emulgen. This is the name under which is brought into commerce a jelly-like mass of acid reaction which is used for the quick emulsification of oils, resins, &c.

According to the analyses made by AUFRECHT the composition is approximately the following, 10 tragacanth, 5 gum arabic, 5 pittosporad, 20 glycerine, 10 alcohol, 50 water.

Emulsions, Apparatus for making, according to FRAIPONT (D. R. G. M. 155793).

Lifting apparatus constructed on the principle of communicating tubes. From the bottom of the reservoir a tube passes downwards and is then again bent upwards, so that it has the shape of a U-tube. The free arm of

this system ends much higher than the level of the reservoir — in fact it reaches as high as the level to which the liquid is to be raised. The real emulsifier is set in just at the point where the U-tube leading from the reservoir turns upwards. It consists of a piece of tubing with very fine channels bored upwards in a slanting direction from the exterior towards the interior, — three rows of holes being usually provided. The perforated piece of tubing is surrounded by casing which is screwed on to a pipe connected with the compressed air supply. When the compressed air is forced through the channels into the liquid contained in the U-tube, the column of liquid contained in this free arm of the tube becomes lighter than the corresponding column of liquid in the arm of the tube leading from the emulsifier. According to the law of the communicating tubes, the column of liquid of the free arm is forced to rise above the level of the column of liquid in the other arm. By a suitable choice in the arrangement of the U-tube and of the emulsifier, liquids may be raised to considerable heights, e. g. 10 metres.

The emulsifier only measures 20 cm in diameter and 35 cm high, and is thus very light and easy to manipulate.

Enamel. By glazes or enamels are meant glazes which are used for coating metals. The enamel must have a very low melting point so that the metals may not oxidize when the glaze is melted on to them.

With regard to the uses of enamel a distinction is made between glazes which are only for ornamenting metals and such as are used to protect the metal from external influences. Ornamental enamel is used especially for beautifying precious stones; on the other hand cast and wrought iron utensils are preferably coated with a protective enamel. They are first brushed, then dipped in dilute H_2SO_4 , freed from rust by brushing again, then quickly dried and coated with a layer of india-rubber. The finely powdered dry glaze is dusted on to the moist layer of rubber and then fused.

Enamel is a glass, the low melting point of which is attained either by the addition of oxides of lead or boric acid (the latter especially for iron wares).

Non-transparent glazes are most commonly used: Enamels may be rendered opaque by the addition of calcium phosphate (bone ashes), oxide of tin, antimony oxide or arsenic.

It is very difficult to obtain enamel of exactly the same coefficient of expansion as the utensils to be coated, so that when change of temperature occurs the glaze becomes cracked. In order to avoid this two or three layers of enamel are usually burnt one on top of the other. Coloured enamels are obtained by the addition of suitable metallic oxides.

Enamel Pigments:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Enesol. The mercury salt of arsenic salicylic acid, obtained by treating an equivalent amount of methyl arsenic acid with basic mercury salicylate.

It forms a white amorphous powder which is soluble to the extent of 4 % in water. It contains 38.46 % Hg and 14.4 % As. On account of its strong tonic action on the central nervous system it is said to find employment in medicine.

Enfleurage. A process for obtaining perfumes, which consists in spreading out the flowers between thin layers of cold fat poured out on glass plates and replacing the flowers daily with fresh ones; after about a month the fat is saturated with the perfume.

For further information see the article on "PERFUMERY".

English red. Reddish brown, red to red-violet paint, which is made either from the naturally occurring blood stone (haematite), or of ochre or bolus, in which case it is impure like all mineral colours, or from the artificially manufactured ferric oxide. Compare also No. 3 in the article on iron colours.

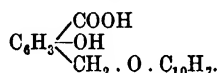
English sulphuric acid see "SULPHURIC ACID".

English yellow see "LEAD PAINTS".

Enzyme see FERMENTS.

Ephedrin. $C_{10}H_{15}NO$. An alkaloid occurring in *Ephedra vulgaris*. Separated from the alcoholic extract of the drug by treatment with ether after the addition of an alkali. It is a strong poison and is used as a mydriatic. A similar alkaloid, PSEUDOPHEDRIN $C_{10}H_{15}NO$ is also known.

Epicarín. A new substance used in medicine. According to its constitution it is β -oxy-naphthyl- o-oxy-m-toluic acid



Epicarín is a pale yellow powder which gradually turns red in the air, and is sparingly soluble in hot water, glacial acetic acid, benzene, and chloroform; readily soluble in alcohol, ether and acetone.

Epicarín is considered as a non-poisonous naphthol preparation; it is a strong poison for skin parasites, on the other hand non-poisonous for warm blooded creatures.

It is prescribed in medicine internally as a non-irritating strongly acting antiseptic. It is however principally used externally for parasitic skin diseases such as itch, herpes &c. &c. It is also used in veterinary practice as a remedy for mange in dogs.

The most usual form for external treatment is the 10 % ointment.

Epichlorhydrin. $CH_2Cl \cdot CH \cdot CH_2$. It is formed when dichlorhydrin is

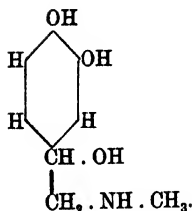
heated with about half its weight of powdered NaOH at a temperature below 130° .

It is a colourless mobile liquid with a smell resembling that of chloroform. S. G. (at 15°) 1.191. B. P. 117° . It is used technically to an increasing extent as it is an excellent solvent for hard resins, nitrocellulose &c. &c. It is also not readily inflammable at the ordinary temperature of working.

Epidermin. Ointment made from white wax, water, gum arabic and glycerine.

The term epidermin is also given to a mixture of fluorpseudocumene and difluordiphenyl in the form of ointment which is used externally for burns, herpes, ulcers &c.

Epinephrine. $C_9H_9O_2N$. A constituent of the suprarenal gland. According to JOWETT it has the following constitution.



Epirenan. Solution of the active substance of the suprarenal gland. This substance appears to be almost identical with adrenaline.

Epsom salts (MAGNESIUM SULPHATE) see "MAGNESIUM COMPOUNDS".

Eradite see "HYDROSULPHITES".

Erbium and erbium compounds, Er. Atomic wt. = 166. Different compounds of this rare metal which forms a grey powder are used occasionally in the incandescent-gas-light industry.

Ergine. A trade name for liquid hydrocarbons (homologues of benzene) obtained by the dry distillation of black- and brown-coal tar oils, said to be used for driving internal combustion engines.

Ergon carbon. A special kind of carbon for arc-light purposes. The light emitted is rich in the ultra-violet rays and is used in various "light cure" processes. It burns away slowly, is completely free from ash and evolves no poisonous gases.

Ergon:

Dr. C. L. Marquart, chem. Fabrik Beuel a. Rhein (Germany).

Erlanger blue see "IRON COLOURS".

Eschel see "COBALT COLOURS".

Eserin see "PHYSOSTIGMIN".

Eserin oil. Solution of 0.2 grm of physostigmin salicylate, which has been dried at 100° C., in 40 grms of olive oil. The solution is brought about by heating the mixture to 150–158°.

The eserin oil is said to find employment in the treatment of diseases of the eye.

Essences. Under this name solutions of volatile oils in alcohol, alcoholic extracts of aromatic plant tissues and alcoholic distillates, are sold.

Essences are used to a very great extent, especially in the manufacture of liqueurs.

Raspberry fruit essence:

Dr. Ernst Kumpf, Villach (Kärnten), Austria.

Essential oils see "OILS".

Esters (ACIDIOETHERS). They are formed by the combination of alcohols with acids. For example $\text{CH}_3 \cdot \text{CO} \cdot \text{OH} + \text{C}_2\text{H}_5 \cdot \text{OH} = \text{CH}_3 \cdot \text{CO}_2 \cdot \text{CH}_2 \cdot \text{CH}_3 + \text{H}_2\text{O}$.

Esters may be prepared either by distilling the mixture of the acid (or one of its salts) with alcohol and H_2SO_4 , or by dissolving the acid (or the salt) in excess of alcohol and passing in hydrochloric acid gas, at the same time heating gently; after this the ester which has been formed is precipitated with water. Esters are also formed by many other methods as for example by the action of acid chlorides or acid anhydrides on the alcohol. A newly patented process for preparing esters is mentioned in the article on ethers.

ETHYLNITRITE see under "ETHYL COMPOUNDS"; FORMICESTER under FORMIC ACID"; other important esters are given in the article "FRUIT ESSENCES"; ACETIC ETHER, (ETHYL ACETATE), and ACETOACETIC ESTER are treated of in separate articles.

Estoral. A menthol ester of boric acid. It is a white powder used as a snuff.

Eternite slates. A slate-like mass which is made from Portland cement and asbestos fibres. In the manufacture the raw materials are treated, as in paper mills, first in the cylinder of a rag machine, and they are then worked up as a pasty mass between two rollers under strong pressure to layers as thin as paper. Several of the latter are then united under great pressure to form one plate.

The eternite slates have the same tensile strength and a considerably higher elasticity than the natural roofing slates. They also offer greater resistance to fire.

Ethers. A class of organic compounds, which are formed by the combination of two molecules of alcohol with loss of a molecule of water. The combination may take place either between two molecules of the same alcohol or between two different alcohol radicles.

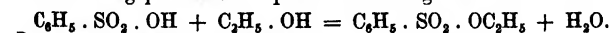
In the former case the result is a simple ether; in the second it is a mixed ether. A simple ether is, for example, methyl ether $CH_3 \cdot O \cdot CH_3$. Methyl-ethyl ether $CH_3 \cdot O \cdot C_2H_5$ is a mixed ether.

The ethers are totally different from, and must not be confounded with, the acid ethers — more properly called "esters" — which are formed by the combination of an alcohol and acid with loss of water; see "ESTERS".

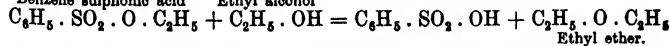
The most important ether is ethyl ether $C_2H_5 \cdot O \cdot C_2H_5$, called simply "ETHER". It is prepared by heating a mixture of 9 parts of concentrated H_2SO_4 (S. G. 1.835) with 5 parts of alcohol of 90 % by volume in a copper retort to 140° . It is of great importance that this temperature should be maintained.

The first product formed is ethyl sulphuric acid $C_2H_5 \cdot O \cdot SO_2 \cdot OH$. This combines with a fresh quantity of alcohol forming ethyl ether and regenerating the sulphuric acid. If the alcohol be allowed to flow continually into the mixture ethyl ether distils over uninterruptedly.

According to a newer process of KRAFT and ROSS (German Pat. 69115) this and other ethers of the fatty series may be prepared by the action of aromatic sulphonic acids on an alcohol of the fatty series. The ether formation in this interesting process takes place in two stages.



Benzene sulphonio acid Ethyl alcohol



Ethyl ether.

By this reaction, which can be most advantageously carried out at a temperature exceeding $100^\circ C$., the sulphonic acid is regenerated and can be continually used again.

The method of preparing ether according to J. W. HARRIS (Amer. Pat. 711585) seems destined to become important. In this process the starting

point is acetylene which is converted by the action of electrolytically produced hydrogen into ethylene. The latter reacts with sulphuric acid forming ethylsulphuric acid, and this in turn is decomposed by water with the formation of ether.

The crude ether thus obtained contains many different impurities. It is first washed with milk of lime and then with water and afterwards rectified over calcium chloride. If ether of the highest purity is required it is submitted to another rectification over metallic sodium wire. The ethyl ether was formerly (according to the older method) manufactured with the help of sulphuric acid, and on this account is still known in commerce under the name "Sulphuric ether" — a term which naturally gives rise to many mistakes seeing that it contains no sulphur.

Pure ether is a colourless very mobile liquid with a refreshing smell: S. G. (at 15° C.) 0.718; B. P. 34.9°. It solidifies at a temperature of — 129° C. to a crystalline mass which melts again at — 117.4°. The vapour of ether is heavier than air. On account of its very low ignition point ether is extremely inflammable. Water dissolves 9 % ether, and ether approx. 2 % water. It is miscible with concentrated hydrochloric acid. When inhaled it produces anaesthesia.

Ether is used in medicine. It is largely employed for industrial purposes as a solvent seeing that it readily dissolves many organic and inorganic compounds. It is most extensively used for dissolving nitrocellulose, that is, for the manufacture of collodion.

Three different classes of ether are sold:— 1. S. G. 0.725, 2. S. G. 0.722, 3. S. G. 0.720 — while absolutely pure ether (free from water and alcohol) has a S. G. 0.718.

TEST. According to the purity the S. G. of ether varies between 0.718 and 0.725. Ether of S. G. 0.725 still contains water or alcohol; on the other hand a S. G. of 0.718—0.720 offers a certain guarantee of its purity. The presence of acids may be shown by shaking 20 ccm ether with 5 ccm water; the latter afterwards must show no acid reaction. To test for hydrogen peroxide and ozone, 10 ccm ether are shaken with 1 ccm of potassium iodide solution in a perfectly stoppered bottle. After standing for an hour in the dark the mixture must show no colouration. The presence of water may be ascertained by shaking ether with anhydrous CuSO_4 . If the latter turn either green or blue then H_2O is present. Another test is to throw a piece of freshly cut metallic sodium Na into the ether: If water is present the metal on standing gradually becomes coated with a yellowish-white layer of hydroxide.

Ether-Distilling and Rectifying apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Ether-Distillations:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Ethyl compounds.

The most important among those compounds which are directly derived from the radicle C_2H_5 are:—

1. ETHYL ALCOHOL (ALCOHOL) q. v.

2. ETHYLAMINE. $\text{C}_2\text{H}_5\cdot\text{NH}_2$. There are many different methods for preparing this compound. Commercially it is prepared according to the method of HOFFMANN, that is, by allowing ethyl iodide or ethyl bromide to act at 100° C. under pressure on alcoholic ammonia. The product of the reaction is ethylamine hydriodide (or hydrobromide). When this is heated with potash the free amine distils over.

According to the Germ. Pat. 143197, ethylamine may be obtained at the cathode by the electrolytic reduction of ethylideneimine $C_2H_5N_2$. The ethylideneimine may be made according to DELEPINE'S process by allowing aldehyde ammonia to stand for several days over H_2SO_4 *in vacuo*. The ethylideneimine is added to strongly cooled sulphuric acid, then brought into the cathode chamber of a well-cooled electrolytic cell and electrolysed at 0° using a superficially oxidised lead cathode. The anode is a cylinder of lead which stands in a porous porcelain diaphragm, and the anode liquid consists of 40–45 % sulphuric acid. An improvement of the last mentioned process is aimed at by the Germ. Pat. 148054.

In order to obtain the amines of the fatty series according to this process, either the condensation-products of the aliphatic aldehydes with ammonia are electrolysed in ammoniacal or neutral solution, or else the mixture of the aldehydes with NH_3 or NH_3 salts is submitted to electrolysis.

For example hexamethylenetetramine may be electrolysed in Na_2SO_4 solution between lead electrodes, in which case the electrolyte is kept neutral by allowing dilute H_2SO_4 to drop into the mixture; instead of sodium sulphate, ammonium sulphate may be used. The resulting mixture of methylamine and trimethylamine is distilled and the separation of these two compounds carried out in the usual way.

The French Pat. 334726 also treats of the electrolytic production of ethylamine.

Ethylamine is a colourless, very mobile liquid; S. G. (at $8^\circ C$) 0.696, B. P. 18° . It is miscible with water in all proportions. It behaves similarly to NH_3 , but is a stronger base, and expels ammonia from its salts.

3. ETHYLANILINE see "ANILINE DERIVATIVES".

4. ETHYL ETHER see "ETHER".

5. ETHYL BROMIDE C_2H_5Br . Obtained by the action of bromine and red phosphorus on 95 % alcohol. At the end of the reaction the ethyl bromide is distilled off, washed with Na_2CO_3 solution, and then with water. After drying with calcium chloride it is distilled.

Colourless liquid of pungent taste and ethereal smell. S. G. (at $13^\circ C$) 1.47; B. P. $38.4^\circ C$. It is used in medicine (*Ether bromatus*) as a narcotic.

6. ETHYL CHLORIDE (*Ether chloratus*). C_2H_5Cl . Obtained by passing hydrochloric acid gas into a solution of $ZnCl_2$ in alcohol.

Colourless ethereal liquid; B. P. $12.5^\circ C$. (so that at ordinary temperatures it is a gas); S. G. at $0^\circ C$ 0.921. It is miscible with alcohol and only sparingly soluble in water; it is used as an anaesthetic.

7. ETHYL IODIDE (C_2H_5I). Prepared similarly to ethyl bromide. Colourless, strongly refracting liquid; S. G. (at $0^\circ C$) 0.975; B. P. $72^\circ C$.

8. ETHYL NITRITE (*Ether nitrosus*) $C_2H_5 \cdot O \cdot NO$. Obtained by the action of H_2SO_4 and potassium nitrite on alcohol.

Yellow, mobile liquid of ethereal apple-like penetrating smell. S. G. (at $15^\circ C$) 0.947; B. P. $17^\circ C$. It is insoluble in water; when ignited it burns with a white flame. It is the active constituent of the official *Spiritus Etheris nitrosi*.

Eucaine. By this name are understood derivatives of γ -oxymethylpiperidine, that is, compounds which are closely related to tropine and cocaine. Usually a distinction is made between eucaines containing carboxyl groups and those which have no carboxyl groups; the former possess a structure very similar to that of cocaine.

α -EUCAINE (alpha-Eucaine; *Eucainum hydrochloricum A*) is the hydrochloride of the methyl ester of benzol-n-methyltetramethyl- γ -oxypiperidine-carboxylic acid. Its preparation is protected by the Germ. Pat. 90245. It is used as a non-irritating local anaesthetic.

β-EUCAINE (beta-Eucaine; *Eucainum hydrochloricum B*) is the hydrochloric acid salt of the benzoylvinyldiacetonealkamine. Its preparation is protected by the Germ. Pat. 97672. Its properties and use are similar to those of the α-Eucaine but it is less poisonous than this compound. It is used in large quantities in the treatment of the diseases of the eye, in dentistry, and for lessening the sensitiveness of wounds, &c.

Eucalyptol see CINEOL.

Eucasin = caseinammonia. Obtained by passing ammonia gas over finely powdered dry casein.

White or yellowish-white powder which dissolves in warm H₂O to a milky liquid. It is a very easily digestible, concentrated, strengthening agent for chlorotic patients and convalescents; it is also used in stomach and lung troubles.

Eucodin. Under this name codeinbrommethyleate is brought into commerce. It forms colourless crystals M. P. 261° C.

Eucodin is recommended in doses of 0.2—0.4 grms as an agent for pacifying irritating coughing, especially in consumptives.

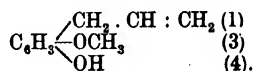
Eudermol = Nicotine salicylate C₁₀H₁₁N₂ · C₇H₆O₃. It is prepared by mixing two separate solutions of 10 parts of anhydrous nicotine and 8.6 parts of salicylic acid, when the eudermol is precipitated. It forms colourless crystals, soluble in water. M. P. 118°.

It is applied in the form of 0.1 % ointments to itching surfaces.

Eudoxin. The bismuth salt of nosophene (q. v.). It forms a reddish-brown odourless and tasteless powder, insoluble in H₂O. It is used in medicine, internally as a disinfectant of the alimentary canal, externally as a substitute for iodoform for wounds and skin diseases.

Euferrol. An iron and gelatine preparation. It is sold in the form of capsules containing 0.012 grammes of ferrous oxide and 0.00009 g As₂O₃. It is prescribed in cases of blood diseases, neurosis, chronic skin disease, exhaustion after long illness &c., &c. Because of its arsenic content it is only given under medical advice.

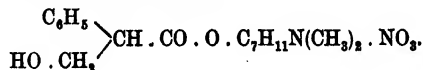
Eugenol. This compound forms 90 % of oil of cloves. It has the constitution



It is prepared from oil of cloves by shaking with aqueous NaOH, acidifying and distilling off the eugenol in a current of CO₂. Eugenol may be readily transformed into iso-eugenol which contains the group CH : CH · CH₃ in place of CH₂ · CH : CH₂. This compound is similar to eugenol but has a very characteristic smell. Liquid of S. G. 1.073 (14°), B. P. 247.5°.

Euguform. Partially acetylated methylene diguaiacol. It is prescribed for external use in irritating skin diseases either in the form of an ointment or of a solution in acetone. It acts as a soothing and anaesthetic agent.

Eumydrine = atropinemethylnitrate



It forms a white crystalline powder readily soluble in water and in alcohol. It is used in medicine in the treatment of the eye diseases (in 1 % solution) as a substitute for atropine, from which it is distinguished by the fact that it is 50 times less poisonous. It may therefore be given with advantage to weak patients.

It has also been prescribed internally in doses of 0.001—0.0025 gramme for different diseases.

Eunatrol is pure sodium oleate. This fatty soap is used internally for the treatment of gall stones, and is usually taken in the form of pills in order to hide the repulsive taste.

Euphorbium. A resin formed from the dried latex of a species of *Euphorbia* found in Morocco. It forms yellowish or brownish brittle, transparent pieces of the size of a hazelnut, and has a burning taste. The dust is very irritating to the mucous membrane. It is used, externally only, in medicine.

Euphorine = phenylurethane. $\text{CO}(\text{NH} \cdot \text{C}_6\text{H}_5)(\text{O} \cdot \text{C}_2\text{H}_5)$.

It is obtained by the action of aniline on the ethyl ester of chloroformic acid.

It is a colourless crystalline powder with a slightly burning taste, sparingly soluble in cold H_2O , more readily soluble in hot water, and very soluble in alcohol and ether. It is used in medicine internally as an antipyretic and antineuralgic as well as an analgetic — especially in cases of headaches, bilious headaches, &c.

It is used externally as an anaesthetic, in powder form, for the treatment of ulcers.

Euphthalmine. It is the hydrochloride of phenylglycolyl-n-methyl- β -vinylidiacetone alkamine. It is used in treatment of the eyes on account of its property of widening the pupils.

Euporphine = Apomorphinebrommethylete. It is prepared by alkylating morphine with dimethyl sulphate, and allowing a saturated solution of potassium bromide to act on the product of the reaction.

Colourless crystalline needles, readily soluble in water and alcohol. M. P. 180°C .

It is said to be used in cases of bronchitis, asthma &c. The largest single dose is 0.02 grm and the largest amount to be taken in one day is fixed at 0.06 grm.

Eupyrine = Vanillin-p-phenetidine. It is obtained by melting together vanillin and p-phenetidine and recrystallizing the fused mass from benzene and petroleum ether. It is prescribed internally in medicine as an antipyretic and astyptic.

Euquinine. Ethylcarbonic acid ester of quinine $\text{CO} \begin{cases} \text{O} \cdot \text{C}_2\text{H}_5 \\ \text{OC}_{20}\text{H}_{23}\text{N}_2\text{O} \end{cases}$.

It is prepared on a manufacturing scale by the action of chlorcarbonic acid ester on quinine.

Delicate white, very light, crystalline needles, not so objectionable in taste as quinine, sparingly soluble in water, readily soluble in alcohol, ether, and chloroform. It can be more easily taken than quinine itself. It has been prescribed with advantage for malaria, whooping cough, bilious headaches, &c.

Europhene = Isobutyl-o-cresoliodide. $(\text{C}_6\text{H}_5 \cdot \text{C}_4\text{H}_9 \cdot \text{CH}_3\text{O})_2\text{I}$.

It is produced by the action of iodine potassium iodide solution on an alkaline solution of isobutyl-o-cresol.

Fine yellow powder, insoluble in H_2O , soluble in alcohol, ether, chloroform and fatty oils. It has antiseptic properties, and is used as a substitute for iodoform in the treatment of wounds — either as a powder (mixed with an equal amount of boric acid), or in the form of a 5–10 % ointment.

Eutannin. Under this name an intestinal astringent is brought into commerce which, according to AUFRECHT, is merely a mixture of gallic acid and milk sugar.

Euxanthic acid see “ANIMAL DYES”.

Evaporation. Evaporation is carried out either by direct firing, or by means of steam, by sand baths, or air baths. The evaporating vessels are dishes of glass, porcelain, earthenware, iron, copper, lead, nickel, tin, aluminium, silver or platinum. Further boilers of the same materials are used, as well as pans, evaporating cylinders, &c. Those apparatus which bring about the evaporation in a chamber, in which the pressure is less than atmospheric, have become of great importance.

Everitt salts see „CYANOGEN COMPOUNDS.”

Exalgin = Methylacetanilide. $C_6H_5N(CH_3)(CO.CH_3)$. Obtained by the action of monomethylaniline on acetylchloride.

Colourless crystalline needles, sparingly soluble in cold water, readily soluble in boiling water, and very readily soluble in alcohol. M. P. $102^{\circ}C$. It is prescribed in medicine internally as an antineuralgic.

Exhaustors.

Exhaustors of Earthenware:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Exodin. The tetramethyl ester of acetylrufigallic acid. According to various investigations it contains various by-products in addition to the principal substance. It forms a yellowish, tasteless, odourless powder, insoluble in water and sparingly soluble in alcohol. It is used medicinally as a mild and harmless aperient.

Expansion. The coefficient of linear expansion of a solid body is the increase in length α of a prismatic bar of length l by an increase of temperature of 1° (more exactly from 0° to 1°); in the same way the coefficient of cubic expansion is the increase in volume 3α by an increase of 1° in temperature. The coefficient of expansion of solid bodies changes with the temperature: a distinction is made between the variable coefficients of expansion — that is, those which are only true for a certain temperature — and the average coefficients of expansion which are calculated by interpolation from different results over a large interval of temperature.

Evaporating Cups of Earthenware:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Evaporating Cups:

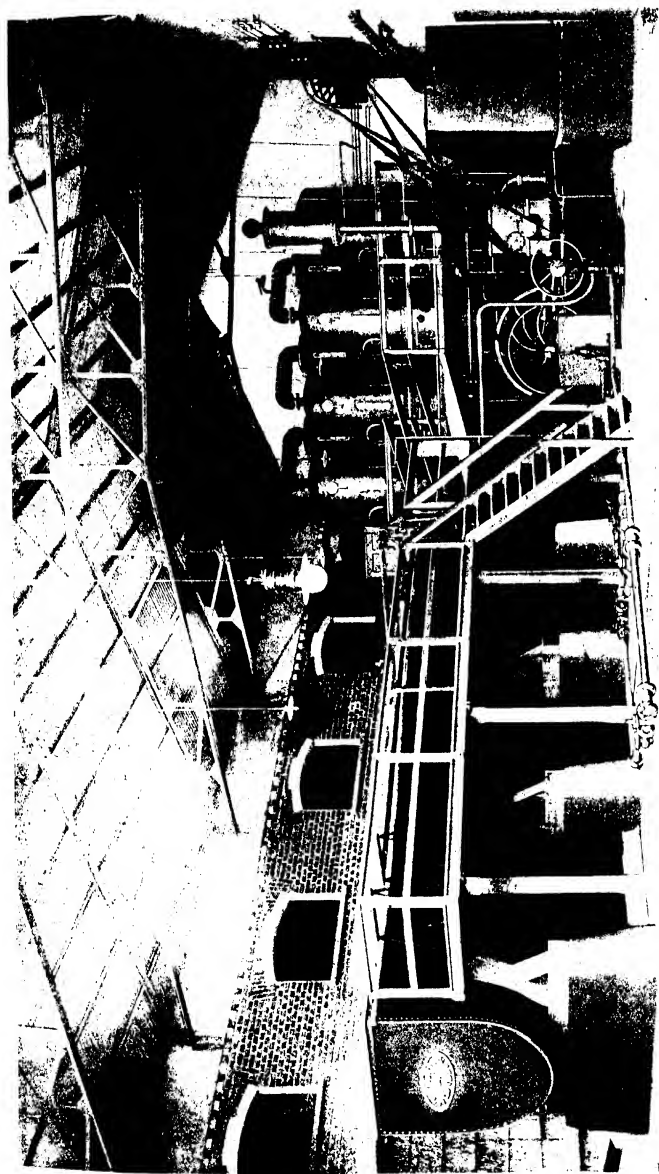
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 5b (see advts.).

Evaporating Cups-Boilers:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 5b (see advts.).

Emil Passburg, 30 Great Street, St. Helen's, London E.C.

Werner Pfeleiderer & Perkins Ltd., Peterborough.



SCOTT PATENT QUADRUPLE-EFFECT VACUUM EVAPORATOR, WITH CAUSTICIZER

(Ernest Scott & Co., Ltd., London)

Evaporating-Apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).
Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Evaporating Plants:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Evaporators and Vacuum evaporators:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Coefficient of linear expansion of solid bodies.

(Seeing that the coefficient of linear expansion only amounts to hundred-thousandths or millionths in the following table the values for 10000 α , and not for α , are given, in order to avoid the ciphers.

Substance	10000	For tempera- ture	Substance	10000	For tempera- ture
Aluminium	0.2221	0°	Hard rubber	0.842	25—35°
"	0.2336	0—100°	Iron, soft	0.1136	0°
Bismuth	0.1316	0—100°	"	0.1228	0—100°
Brass (73.7 Cu + 24.2Zn + 1.5 Sn + 0.6 Pb) ..	0.1840	0—100°	Iridium	0.0669	0°
Black coal	0.2811	0—100°	"	0.0708	0—100°
Bronze (86.3 Cu + 9.7 Sn + 4 Zn)	0.1782	40°	Lead	0.2829	0°
Bronze (86.3 Cu + 9.7 Sn + 4 Zn)	0.1802	0—100°	"	0.2984	0—100°
Cast iron, grey	0.1061	40°	Nickel	0.1262	0—30°
"	0.1075	0—100°	Platinum	0.007	0—100°
Cast steel (Krupp)	0.1069	0—30°	Silver	0.1935	0—100°
Cobalt	0.1244	0—100°	Tin	0.2290	0—100°
Copper	0.1627	0—30°	Wood:		
"	0.1698	0—100°	Ash, longwise	0.0951	0—100°
Glass:			Box wood, longwise	0.0257	2—34°
soft	0.0883	0—100°	Hornbeam, longwise	0.0604	0—100°
mirror	0.0891	0—100°	Maple, longwise	0.0638	2—34°
Jena XVIII	0.0844	0—100°	" crosswise	0.484	2—34°
Gold	0.1451	0—100°	Oak, longwise	0.0492	2—34°
Hard rubber	0.770	17—25°	" crosswise	0.544	2—34°
			Pine, longwise	0.0541	2—34°
			" crosswise	0.341	2—34°
			Zinc	0.2811	0—30°

With liquid bodies of course only the coefficient of cubical expansion comes into consideration; the coefficient of the cubical expansion of mercury is of special importance (with regard to the correction of thermometer and barometer scales). According to the experiments carried out by WUELLNER it amounts to,

between 0—30°	0.0001812
" 0—100°	0.0001825
apparent, (in the glass)	0.0001544

For gaseous bodies the coefficient of expansion is, according to law of BOYLE-GAY-LUSSAC, without consideration of the nature of the gas, a constant, and amounts to $\frac{1}{273} = 0.003663$. It may be remarked that these constants only apply to conditions under which the gases do not approach that point at which they liquefy.

Explosion proof vessels. These are vessels of iron or other sheet metals for storing explosive liquids. The principle of the so-called explosion proof vessels "Salzkottener" consists in combining protecting arrangements which

1. prevent an explosion when a flame is applied directly to the contents of the

vessel, and 2. protect filled and stoppered vessels, which are exposed to fire (for instance in burning houses), from bursting.

The protecting arrangements, which are applied to all openings of the vessels, consists of cylinders of fine metallic wire-netting; the wire netting is also wrapped in a protecting mantle of perforated sheet iron in order to prevent injury to the wire-netting cylinder. The effect of this wire netting cylinder, which is applied to all openings of the receptacle, is of such a nature that when a flame is brought near, the heat is quickly conducted away and the flame thus prevented from striking through the netting. The above mentioned perforated protecting mantles, besides the protecting power they possess, help to cool a flame considerably on account of their polished metallic parts, and in this way increase the effect of the whole protective arrangement. In vessels containing explosive liquids which are provided with the above mentioned protecting arrangement, the gases, on being ignited, burn with a quiet flame outside the vessel so long as the liquid evaporates. Thus the protecting arrangement corresponds in principle to the DAVY safety lamps.

One of the existing arrangements prevents a flame, which has been brought near the contents of the vessel, from striking through, so a second protecting arrangement is provided which prevents a filled and stoppered vessel from bursting when heated from the outside. This second contrivance is a safety plug. It consists of a screw plug in the middle of which a metal plate is soldered by means of a readily fusible alloy. At a certain temperature and pressure — the alloy varies according to the purpose for which the vessel is required — the gases force the loosened plate out of the plug. By this means the extra pressure is removed at once, and the escaping gases can become ignited on the outside, and quietly burn away, while a "striking back" of the flame towards the inside is made impossible by the above mentioned wire cylinder.

The manufacture of explosion proof vessels, which are of great importance, in chemical industry, is protected by German patents.

Explosion proof transport vessels with safety plugs for benzine, ether, spirits, carbon disulphide, acetic ether, &c. are made, according to the nature of the liquid, of sheet-iron coated with lead or tin.

Extinguishers see "FIRE EXTINGUISHERS".

Extracts. Solutions prepared for medicinal purposes. The substance to be extracted is finely ground, heated with water, kept boiling for 30 minutes, and then pressed out.

The details for the preparation of different extracts vary according to the substance to be extracted. The German Pharmacopeia recommends mixing the substance with cold water, heating on the water-bath for half an-hour and then pressing. When the quantities are not specified 1 part of material to 10 parts of extract are taken, the only exceptions being cases where maximum doses are recognized.

Where the substances are of a mucous nature the ratio of substance to extract is left to the discretion of the pharmacist.

In the preparation of extracts of *ALTHAEA* and *LINSEED*, cold water is employed. The cut roots or whole seeds are soaked in cold water for half-an-hour without stirring, and the mucilaginous extract decanted from the residue. In medicine usually four grades are distinguished, according to the viscosity, namely, liquid extracts (fluid extracts), thin extracts, thick extracts, and dry extracts. The extract is prepared by evaporating the natural sap or a solution; the latter may be an aqueous, alcoholic, or ethereal infusion or decoction.

According to the Germ. Pat. 151208 for the preparation of extracts for medicinal purposes the substance to be extracted (preferably in the form of a

powder) is mixed with liquids which contain fermentable carbohydrates, and then left to the alcoholic fermentation, after which it is evaporated in the ordinary way. For example, in order to obtain a medicinal wine the corresponding substances are fermented with unfermented grape juice.

The Germ. Pat. 148906 has in view the preparation of vegetable extracts which do not become milky in lemonade. In order to free the respective extracts from the albuminoids and pectin they are treated at a high temperature for 15–30 minutes with carbonic acid gas under pressure; the precipitated stuffs are then separated by means of a filter press from the liquid.

Extraction.

Extracting apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).
Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Extracting apparatus of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Extraction wax see "WAX".

Extraits d'odeur see "PERFUMERY".

F

Fastness of dyes. See also COTTON DYEING, MIXED GOODS DYEING, JUTE DYEING, LINEN DYEING, SILK DYEING and WOOL DYEING and VAT DYEING and finally TURKEY RED DYEING. In this article the various methods of testing the durability of the dye are given.

TESTING THE FASTNESS OF COLOURS.

The question as to whether a colour produced can resist the action of external influences, in other words, whether it is sufficiently fast, is of great importance to the dyer so that tests for proving this point are of considerable importance.

As the idea of fastness is not self evident, it must be defined. A colour is fast when in use and when subjected to the influences to which it is exposed in the ordinary course of things it still keeps the original tone, tint and freshness. Therefore it follows that the idea of fastness must vary according to the purpose for which a given fibre is intended, and further it is not sufficient to separate the dyes into fast and fugitive, but to classify them according to the degree of fastness. Whether a colour is fast or not, or whether it is suitable for dyeing purposes must be determined by a consideration of the influences to which the fibre will be exposed and the purposes to which it will be applied. The following points must also be taken into consideration what change the colour suffers and whether the colour rubs or "bleeds" (i. e. colours other fibres worked up with it).

The tests can best be carried out on large quantities, but as these would be too costly and take too long to carry out, the dyer usually satisfies himself on this point by experiments on a small scale. We here append the ordinary tests, adding however that the test is in no wise to be strictly followed, but must be varied for the special cases, the principal point being that the test must follow as exactly as possible the practical conditions.

1. FASTNESS TO WATER.

Cottons, woollens, silks and other woven materials are those which are exposed to the influence of water or rain. Loose fibres or threads of the material in question are plaited together with undyed threads and placed over night in water. The water should then show no colour and the undyed threads remain colourless. Or, a piece of dyed material is tacked on to a somewhat larger undyed piece and then treated as above. Very frequently the test samples are not laid in water but only sprinkled and allowed to dry slowly. Materials intended for flags should stand repeated sprinkling and drying without staining the undyed parts. Distilled water is best for these experiments.

2. FASTNESS TO WASHING.

A colour fast to washing is one which can resist the influences to which it is exposed when washed by the ordinary household methods. It is of course taken for granted that the washing is carried on in a reasonable manner suited to the nature of material in question. As domestic washing is usually done with soap and water the term fast to soaping is often used. A half percent soap solution (5 g of soft soap in one litre of water) is used for this experiment. It is usual however to increase the strength of this solution by adding also 3 g NaOH to each litre of water.

Wool is washed for three quarters of an hour in the soapy solution at a temperature of 50–60° C. and then well rinsed and dried. If the dye stands this treatment, it can be repeated, increasing the time to not more than one hour.

Should a material of one colour only run a little during the first washing it is of no great consequence, but it must be remembered that in a household different coloured garments are often washed together. It is therefore advisable in this experiment also to make a plait of dyed and undyed woollen thread or to sew a piece of the dyed material on to a larger white piece. A still better method is to take a sample of white wool, white cotton and white silk and plait or sew all these together with the dyed piece in order to be quite sure that the dye in the soapy water will not stain any one of them.

As a rule cottons are very frequently washed so that the experiments with such materials should be still more drastic. The cotton pieces or plaits are washed in the above given soda and soap solution at a temperature of 50–60° for one hour, then rinsed in water and dried. After this they are again washed for an hour, rinsed and dried, and the process is repeated for the third time. In case the material is knitting cotton or any such material it should be able to stand boiling for two hours without the white threads becoming stained.

Coloured silk materials are tested by washing several times in a luke warm (40° C.) solution made of 5 g of Marseilles soap in 1 litre of water. In this case also the dyed sample should be plaited or sewn together with some white silk, cotton and woollen pieces to make sure that none of the dye stains these materials. Coloured silk is for many purposes woven with raw silk, and cotton, and boiled off after this process. In such cases the dye should not tinge the white silk or cotton even after having been boiled for two hours in a strong lye of 15 g of Marseilles soap to one litre of water.

3. FASTNESS TO MILLING.

The most reliable method is to carry out this test on a large scale, using the same kind of milling machine that will be used for the bulk. As this however is very troublesome and not possible in all cases, the test must often be carried out in a small sample. Indeed this can be done with advantage even where the necessary apparatus is available.

The dyed sample is closely plaited with white wool, silk and cotton, and then thoroughly kneaded for some time in luke warm water and soap. For this purpose 100 g of ordinary fullers' soap are dissolved in one litre of water and into this the sample is placed for two hours, the solution being kept warm, and thoroughly kneaded. If the goods are to be subjected to very heavy milling 2—5 g of soda can be added for each litre of solution, while for light milling a lye of 30 g of soap and 2 g of soda per 1 litre is sufficient. After the milling is finished the lather should show no appreciable colouring — the sample is well washed with water and dried very slowly on moist blotting paper. Care must be taken to wash the sample very thoroughly or it will be difficult to ascertain whether the colour runs or not. This test when carried out with a small piece by hand is not always reliable as the effect is never quite so drastic as proper milling, so that before guaranteeing the colour the latter process should be carried out.

4. FASTNESS TO STREET DIRT.

This experiment is carried out with alkalis since street dirt and dust have an alkaline reaction; consequently the fastness of dyes to dirt and dust is often spoken of as fastness to alkalis. Woollen stuffs are usually sprinkled with a solution of 10 g of ammonia in one litre of water; and then dried without rinsing, after which they are well brushed. Or the material can be laid for a time in the above solution and then dried without rinsing. Instead of ammonia, lime water, containing 10—15 g of quick lime in one litre can be used. After drying and brushing any change in the colour where the alkali has been sprinkled can be easily observed. A 5 % soda solution in luke warm water is a test sometimes applied. It is however not very certain. The best test of all is probably to submit a sample of the goods to the actual street dirt.

In cases of cotton goods the fastness to strong caustic soda solutions such as are used for mercerising, has often to be tested. The experiment should then be carried out in precisely the same way as in mercerising. The dyed cotton is plaited with white, treated for 5 minutes with cold caustic soda lye, 25° to 30° Bé., then washed in cold water, once more well washed in hot water and finally acidified with a little weak acetic acid. After these processes no appreciable change of colour or tint should be noticeable.

5. FASTNESS TO ACIDS.

Coloured woollens must be tested for fastness to sulphuric acid when carbonised. The goods are placed in cold dilute sulphuric acid of 4° Bé. and then squeezed out and dried between undyed woollen material for 2 hours at a temperature of 85—90° C. The fabric is then passed through a cold solution of caustic soda of 4° Bé., rinsed in water and dried. Colours less fast to acids are carbonised with aluminium chloride. These fabrics are tested with a solution of the salt (5—7° Bé.) well wrung out after soaking and dried at a temperature of about 110° C. after which they are treated with fuller's earth and again dried.

Cotton goods are tested by laying them for 20 minutes in acetic acid of 8° Bé., thoroughly washing and drying.

Another sample of the same goods is then treated in the same way with hydrochloric acid of 3° Bé. and a third, which is plaited or sewn together with white material is boiled for from one or two hours in a bath, containing 1 g of sulphuric acid and 2 g of GLAUBER'S salt (sodium sulphate) per litre. In all three cases the dye should lose little in intensity, and the white wool should not be coloured. Silk seldom needs to be acid proof, but if necessary it can be tested with a luke warm bath, containing 1 g of sulphuric acid per 1 litre.

6. FASTNESS TO BLEACHING.

Woollens and silks which can resist the effects of sulphur can as a rule be guaranteed as fast. The dyed wool or silk is damped and hung for some hours (at least 8) in a sulphur chamber, then well rinsed and dried. It is still better first to place the dyed woollen or silk fabric (mixed with white wool, silk and cotton) in a soap bath of 5—6 g of Marseilles soap per litre of water, rinse, wring out and then proceed as above. For exposing small samples to sulphur, a wooden box or a glass shade is placed on a glass plate. The sulphur which is put in a small wooden box is ignited and the cover immediately replaced. The samples must hang freely in the sulphur vapour e. g. from a wooden frame. The dyed materials can also lie for 12 hours in an aqueous solution of SO_2 ($4\frac{1}{2}$ Bé.) after which they should be well rinsed and dried.

Cottons which can resist the action of chlorine do not fade. The dyed cottons are sewn or plaited with white and exposed to a weak solution of chloride of lime and then placed in an acid bath. The chloride of lime solution should not be stronger than $\frac{1}{2}^\circ$ Bé. The material should lie in this for 1 to 2 hours, after which it is washed, drawn through very weak sulphuric acid (S. G. 1.005) rinsed and dried.

In special cases resistance to the action of hydrogen peroxide determines that the colour is fast. 1 part of ordinary hydrogen peroxide (12 vols.) is diluted with 5 parts of water to which is added sufficient ammonia to render it alkaline, and in this the dyed material is placed for two hours, then rinsed and dried.

7. FASTNESS TO RUBBING.

The goods chiefly concerned under this heading are furniture coverings and clothing. The dyed material is stretched out flat, e. g. on a smooth board, fastened with drawing pins and rubbed hard with white cotton material or rough white paper. The colour should in this case not rub off, that is the paper or cotton should show little or no traces of colour. This test is best carried out by rubbing in exactly the same way another piece of material of which fastness is known. One piece is rubbed with the right and the other with the left hand.

8. FASTNESS TO PERSPIRATION.

The nature of human perspiration varies so much in different individuals, that the same material of the same shade dyed by the same process will in one case be changed with remarkable rapidity, while in another the individual can wear it for a very long time without the least loss of colour.

An approximate test can be made by exposing the material to the action of acetic acid of 2—3° Bé. at the body temperature, 37°. It is repeatedly soaked in the acid and allowed to dry, between each soaking. The treatment should be repeated 4 to 10 times at intervals of one day. As treatment with acetic acid however gives no certain guarantee, it is preferable to have samples of the material worn on the body, under the arms or on the breast by different people, those persons being chosen who perspire profusely. Also the test should be made when these persons are doing heavy manual labour or taking very long walks, &c.

9. FASTNESS TO IRONING.

The material in question is ironed with a very hot iron in exactly the same way as the process is usually performed. It can be ironed either dry or after having been damped, or a wet white rag is laid over the material, which is then ironed until the rag is dry. The colour should not change on being ironed, or the slight change which immediately appears should pass off after the material has cooled.

10. FASTNESS TO BRIGHTENING PROCESSES (LUSTERING).

To imitate the effect of wet brightening, the dried samples after being sewn or plaited with white cotton silk, and wool are placed in boiling water. They are then well worked and kneaded from time to time by hand and finally allowed to cool in the water. The dry process is imitated by exposing the material to the effect of high pressure steam at a temperature of 110° for half an hour, one piece being first wetted, while another is treated thus in a dry state. It is of course preferable if a lustring cylinder is available, in which case the sample is steamed together with a large piece which is undergoing the same process.

11. FASTNESS TO LIGHT.

In practice fastness to light includes fastness to air, heat, moisture, dust, &c.

In other words the colour must be weather proof. Therefore as a rule the samples should not be exposed to light behind glass, but should be placed in the open air so that they are actually subjected to the influence of wind and weather. At the same time it is advisable to test if the goods are, in the strict sense of the word, also fast to sunlight, which is best done by putting the sample in a photographic copying frame behind glass and exposing to the sun's rays.

If it is required to ascertain wher the colour is weatherproof, the sample (whether woven yarn or thread) is fastened on a board and half covered with a piece of opaque cardboard. It is a good plan to place another sample of the same tint which is known to be fast beside the one which is being tested and to expose both to the same conditions. Further, materials of exactly the same shade should not be taken alone but pale, medium and dark samples, or even further shades should be used for the purpose of this test. Comparative examinations should then be simultaneously made (not one after the other), since the effect of light varies considerably according to the time of the day, the weather and the season.

The change in the colour is determined from time to time (say every week) by covering another strip of the pattern with the cardboard, so that after the test has been sufficiently carried through the material will show a graduated scale, which marks the fastness.

The results thus obtained however should not be applied to materials other than those experimented upon, for dyes which are very fast to light when dyed on silk or wool are not so when dyed on cotton.

In testing the fastness of a dye to light, the purpose to which the material is to be applied should be taken into account. The depth of colour and the extent of the exposure must also be considered.

If tests of fastness to light have to be made frequently it is well to have samples of shades which can be used for comparison, these must, of course, be themselves very fast. For blue shades indigo is good for this purpose; for yellow, tartrazine, and for reds, alarizine red, &c. are suitable.

Whatever test is performed, a pattern or part of the dyed material should be always retained for comparison. This point cannot be sufficiently emphasized.

Fats and oils. These are generally mixtures of the triglycerides of the fatty acids occurring in the vegetable and animal kingdoms. For practical purposes they are divided into animal and vegetable fats, and again into solid and liquid (i. e. at the ordinary temperature). The liquid vegetable fats are generally called *oils* which are divided into *drying* and *non-drying* oils.

Solid vegetable and animal fats chiefly contain glycerides of palmitic and stearic acid, and in smaller quantities, glycerides of oleic acid, while the liquid

animal fats and the non-drying oils consist chiefly of the glycerides of oleic acid. In the drying oils the glycerides of linoleic acid predominate.

Pork fat, beef suet, mutton suet, goose grease &c. are solid animal fats, while bone oil and the various fish oils are liquid.

Palm oil, cocoa nut oil are solid vegetable fats. Amongst the non-drying liquid vegetable fats are olive oil, rape-seed oil, castor oil, almond oil, cotton-seed oil, mustard oil &c., &c., while poppy-seed oil, linseed oil, nut-oil, &c. are drying oils.

Related to fats are the various kinds of wax (insect wax, spermacetti and vegetable wax) and lanoline.

The fats and oils mentioned are treated so far as they are of industrial importance in separate articles. Care should be taken to distinguish from these fats and oils the ESSENTIAL OILS (see "OILS, ESSENTIAL") and the MINERAL OILS (see "MINERAL OILS" and "GREASES"). See also "RESIN OILS", "LANOLINE", "VASELINE", "WAX", "WAX, VEGETABLE" and "SPERMACETI". The *Huiles antiques* are mentioned under "PERFUMERY".

Fats and oils are lighter than, and completely insoluble in, water, but are soluble in ether, benzene, benzine, carbon disulphide &c. They are (distinction from the essential oils) not volatile, and boil between 300 and 320° with decomposition. They do not burn easily, though with a wick give a luminous flame.

The fats and oils are obtained by various methods. Animal fats are generally obtained by a process of melting, the heating being effected either over a free flame, or by steam. Another method is the subjection of the raw material to cold or hot pressure; this method is generally used in the case of vegetable fats and oils and as in the third method it is combined with a process of treating with suitable solvents (extraction).

All methods necessitate a preliminary treatment, viz. the mechanical destruction of the envelope of the fat.

The raw material thus prepared must for most purposes be refined, by a process of standing and filtering (in filter presses) and treatment with suitable reagents (generally H_2SO_4).

Fats are usually bleached with chlorine. More recently ozone has been used with good results (see "BLEACHING" and "OZONE"). Further potassium permanganate and hydrochloric acid, air and, chromic acid have been used, and bleaching in sunlight with subsequent washing with hydrochloric acid is recommended. Bleaching with silicic acid or silicates has also become important; of the silicates, bleaching earth (*Florida earth*) has been largely used. This is an aluminium magnesium-hydrosilicate ($4 MgO, 3 Al_2O_3, 25 SiO_2$) which is rendered anhydrous and then mixed with the oil warmed to 60–80° C. The mixture is then passed through a filter press while the residue is subjected to dry distillation, or the residual oil extracted after roasting.

According to one method (patent applied for in Germany) the fats are first purified by neutralization with a concentrated solution of Na_2CO_3 , washed with H_2O and then mixed with a solution of an alkaline earth compound ($CaCl_2$ -solution). The fats are then filtered and finally heated to 100° C. for some considerable time.

According to the Germ. Pat. 154755 oils and fats are purified by vacuum distillation, in a special apparatus which allows of continuous working. It is doubtful whether this method, which is rather expensive, will be capable of industrial application. — According to Germ. Pat. 166866 oils are preserved and refined by treatment with hot indifferent gases. The free acids so formed are neutralized with dry gaseous ammonia, the excess of which can (after removal of the soap) be got rid of by heating.

The heating by the gases removes water, sterilizes the fats and coagulates the proteid matter.

Many attempts have been made to recover waste oil &c. The Germ. Pat. 141203 proposes obtaining the oil from refuse waters by extraction in an apparatus in which the oil-containing waters &c. are thoroughly mixed with the solvent.

Another Germ. Pat. 140399 separates oil from condenser water by making the latter pass through an apparatus into which a slow current of CO_2 or air is blown. This patent has, however, been cancelled.

According to Germ. Pat. 135313 the oil in the mud of sewage water is obtained by first warming the mud with H_2SO_4 , pressing and finally drying and extracting the residue.

The Germ. Pat. 149613 obtains fat and oil from fish residues, intestines and other offal by heating the raw material in autoclaves and at the same time introducing compressed air.

Of considerable importance are the attempts to obtain fat from faeces. The methods of PICK and ARNOLD are the most noteworthy and are used in America on a large scale. The faeces in a concentrated form are boiled with H_2O in closed steel cylinders and then pressed out hot under a pressure of 100 atm. An impure fat separates from the liquid which is purified by repeated boiling in H_2O . This is said to be a commercially useful substance. It is a transparent and almost odourless oil; the expressed residues are dried and used as manure.

The Germ. Pat. 145389 recommends liquefying the faeces with warm water and then emulsifying with benzene and a little H_2SO_4 in an apparatus provided with stirring gear. After settling, the benzene solution of the fat collects on the surface, is placed in a distillation apparatus and the fat obtained by driving off the benzene. The residue is said to be odourless and to form a good manure.

A method of using city refuse for obtaining fat is protected by the Germ. Pat. 150778, 153330 and 153331. The apparatus is such that the refuse waters rise in it, the fat gathers at the top while the clarified water enters a second vessel, separated from and surrounding the former. Here the last traces of fat are separated and the water flows into the third, and widest vessel. This surrounds the first two and is provided with a spout at the top. The supplementary patents deal with improvements in the apparatus which can then be used as a preliminary purifier in the bacteriological method for the purification of sewage (see "WATER PURIFICATION").

According to the Germ. Pat. 159170 the faeces are saponified by mixing them with caustic alkalies or alkali carbonates and drying the mixture at $120-125^\circ$. Another method is to boil the mass after adding the bases. The soaps obtained are extracted with warm H_2O and the fatty acids separated from the separated and filtered solution of fat by acidification. The fatty acids are extracted with a suitable solvent and are used in manufacturing stearin and candles. — The process however is probably much too expensive for industrial purposes.

See "FATTY ACIDS" for the process of SAPONIFICATION".

TEST: PARTHEIL and FERIE (Arch. Pharm. 1903, 561) have worked out the following method for the analysis of fats (Chem.-Ztg. 1903, Repert. 314):

About 1 g fat is saponified with 15 cc $\frac{1}{2}$ n. alcoholic potash on the water bath and the soap is dissolved in 100 cc of 50 % alcohol. After adding phenol and phthaleine the excess of alkali is neutralized with dilute acetic acid, and the lithium salts of the higher solid fatty acids are precipitated with a 10 % solution of lithium acetate in 50 % alcohol. The mixture is warmed on the water-bath to 60° when the precipitate redissolves. On cooling, the lithium salts of stearic acid, palmitic acid and the greater part of the myristic acid separate in crystals. The whole is then dissolved in 100 cc hot absolute alcohol. On

cooling the stearate and palmitate separate, are filtered off, dried and weighed, while the myristate remains in solution. The solution is evaporated and the myristate dried at 100°C . and weighed. It is then decomposed by hydrochloric acid and the washed and dried myristic acid estimated by titration. The acids of the stearate and palmitate mixture are also set free by hydrochloric acid and either titrated after washing with alkali or converted into barium salts. The amount of stearic acid and of palmitic acid is calculated from the molecular weight determined by some method. In the filtrate from the precipitated lithium salts there are present the salts of a small amount of myristic acid, lauric acid, oleic acid and acids of the linseed oil series (if these last are present). According to FARNSTEINER these are converted into lead salts by a solution of lead acetate. The lead salts of the saturated and unsaturated acids are then separated by treatment with hot benzene. After weighing the lead salts of the saturated fatty acids the latter are set free with hydrochloric acid and the amount of myristic and lauric acids calculated from their mean molecular weight. From the solution of the unsaturated fatty acids the solvent is distilled off in a current of hydrogen and the residual lead salts are decomposed with dilute hydrochloric acid. The free fatty acids obtained are dissolved in alcohol, neutralized with potash (using phenol phthaleine as indicator) and converted into barium salts by a 10 % alcoholic solution of barium acetate. The barium salts of the linoleic acid series are extracted with aqueous ether and the weight of the barium salts soluble in ether, and that of the barium oleate determined.

Refractometrical test after Wolny and Utz:

With the Butter-Refr. or Abbe's Refr. of Carl Zeiss, Jena. Prosp. Mess. 172, 173.

Fat colours. These are insoluble in water but soluble in mineral, plant and animal oils, in benzene, benzine, naphtha, paraffin, turpentine, linseed oil, tallow, stearine, wax, &c. Also soluble in CS_2 , ether, acetone, amyl acetate and alcohol.

They are used for the preparation of printing colours &c. for colouring wood, leather, candles, soaps, pomades, butter, margarine, &c.

Fatty acids. For details of the process of decomposing glycerides (fats) into salts of the acids and glycerine (saponification) see "SOAP".

The process of saponification is carried out in various ways. 1. **LIME SAPONIFICATION**, formerly effected in open boilers, now however under pressure in autoclaves. Usually 3% lime (in the form of milk of lime) under a pressure of 10 atm. is used. The lime soap obtained is then split into fatty acid and CaSO_4 by treatment with H_2SO_4 . As plaster of Paris is nearly valueless an attempt has been made to substitute baryta for lime. Sodium aluminate has also been recommended. Recently saponification under 12 atm. press. with an addition of 0.5—1 % of magnesia has become important and appears to be gaining ground. It has been found that magnesia soaps though insoluble in H_2O , dissolve in non-saponified fat, and are therefore important emulsifying agents. The actual decomposition in the processes mentioned is effected by the water only. Saponification in autoclaves is said to be of still greater advantage when ZnO is used instead of MgO .

2. **DECOMPOSITION BY HIGH PRESSURE STEAM.** A method formerly used which consisted in heating the fat emulsified with 30—50 % H_2O to $300 - 350^{\circ}\text{C}$. in autoclaves. Saponification has also been carried out with superheated steam.

Further should be mentioned the decomposition of fats with H_2SO_4 , especially useful for very impure material: The fat is first melted so as to remove the impurities, heated to $110 - 170^{\circ}$ in a stirring apparatus with steam and H_2SO_4 of 66 Bé then added; the amount of H_2SO_4 depends on the kind of fat,

varying between 2 and 10 %. The fatty substance foams up strongly when H_2SO_4 is added, gives off SO_2 and turns brown. It must be stirred well for several hours, after which it is run into water. This mixture is heated to 100°C . by steam coils and the fatty acids begin to collect on the surface. They are taken off and purified. The H_2O in the residue is removed by heating and the dry mass distilled at 300° . Saponification by H_2SO_4 is effected in various other ways.

For the methods of fat decomposition usually employed in soap manufacture, see "SOAP".

Much interest has lately been roused in the decomposition of fats by enzymes. This method, first published by CONNSTEIN, HOYER and WARTENBERG (Ber. d. deutsch. chem. Ges. 1902, 3988) appears to be destined to produce a complete revolution in the manufacture of fatty acids and soap. The new method is based on the use of fat-splitting ferments found in various plant seeds. Castor oil seeds contain much of this ferment and are used exclusively for this purpose. The ferments are allowed to act on the fats in presence of slightly acidulated water. According to a paper read by CONNSTEIN at the Intern. Congr. for Applied Chemistry, Berlin 1903, and according to the wording of the patents obtained since (Germ. Pat. 145413 and 147757) the castor oil seed is well mixed (after grinding) with the fat and dilute acid (acetic acid or sulphuric acid) and a temperature of $20\text{--}40^\circ$ maintained. Instead of free acids acid salts may be used, e. g. solutions of sodium bisulphate or sodium phosphate. In the paper mentioned above CONNSTEIN reported that the actual process for saponifying 500 kg palm oil would be as follows: 50 kg well-ground castor oil seed is stirred with part of the molten fat cooled down to $30\text{--}35^\circ$. It is decanted from the vats and mixed with the bulk of the fat in a conical vessel of wood or aluminium. 300 kg 0.12 % acetic acid is added and the mixture kept in motion by air currents. After 24 hours about 90 % of the fat is decomposed. The emulsion is destroyed by warming and adding H_2SO_4 . Three layers are formed which are separated: 1. a great quantity of acid aqueous glycerine, 2. a small layer of emulsion containing dilute glycerine, fatty acid, and seed particles, 3. 95 % of the clear pure fatty acid. The glycerine is recovered by washing with water and subsequent boiling with caustic alkalis or alkaline carbonates. The soap is salted out and rinsed once or twice with weak salt solution.

According to investigations by BRAUN and BEHRENDT, *Abrin* may be used with advantage for the fermentative decomposition of fats. The *abrin* must not however be purified, so that possibly a hitherto unknown constituent of the *Abrus* seed is the actual fat-splitting ferment.

Another singular method of decomposing fat is given by E. TWITCHELL: The fat is split by boiling in open boilers with steam, adding a fat splitting medium composed of benzene-stearol-sulphonic-acid $\text{C}_6\text{H}_4(\text{HSO}_3)(\text{C}_{18}\text{H}_{35}\text{O}_2)$.

When the splitting has taken place in one of the above-mentioned ways, in order to separate the liquid from the solid fatty acids the saponified mixture is repeatedly washed with acid and H_2O , re-melted and placed in shallow vats which are cooled then solidification takes place. From the solid fatty acids thus obtained the last traces of liquid fatty acids are removed by hydraulic pressure, at first cold and then with slight warming.

Besides those mentioned there are other methods in use. The raw material is mutton fat, Russian tallow (a mixture of beef and mutton fat) or crude palm oil. Solid fatty acids are sold as stearine (see special article), the liquid ones as saponified oleine.

For the purification of the fatty acids Germ. Pat. 164154 recommends converting them into their respective esters (e. g. by heating with methyl alcohol and conc. H_2SO_4). These are distilled in a current of steam and then decomposed into acid and alcohol by heating in autoclaves.

It remains to be seen whether the method is feasible on a large scale.

The contents of the Germ. Pat. 141029 are remarkable. According to this patent the glycerides of unsaturated fatty acids or the acids themselves can be solidified by heating them in a strong current of hydrogen in presence of finely divided nickel, which acts as a contact substance. Oleic acid is said to be converted almost completely into stearic acid.

According to the Germ. Pat. 148062 fats containing oleic acid and oleic acid itself are converted into solid fatty acids by treatment with concentrated H_2SO_4 ; this method is well-known, but the product is always of a dark brown colour; and has to be distilled with superheated steam, when a portion of the oxystearic acid thus formed is reconverted into liquid oleic acid. According to the new method the fatty acids are first distilled with superheated steam and then treated with concentrated H_2SO_4 ; no carbonisation takes place in this case, and the dark colour is removed with zinc dust. Germ. Pat. 150798 has for its object the conversion of oleic acid by means of H_2SO_4 . Equal molecules of oleic acid and anhydrous H_2SO_4 are allowed to act on each other at a temperature of $60-90^\circ C$.

According to Germ. Pat. 166610 solid fatty acids are prepared by first treating the liquid fatty acids with H_2SO_4 , washing to remove the acid, neutralizing with an oxide or carbonate and then distilling in a current of hydrogen under reduced pressure. By this means the unsaturated are converted into saturated acids.

According to Germ. Pat. 167107 the addition of hydrogen to unsaturated fatty acids can be accomplished by an electric discharge.

The Germ. Pat. 151880 protects a method for the preparation of fatty acids from crude naphtha, petroleum, and other hydrocarbons. The suitable fractions are chlorinated and then successively treated with magnesia and carbonic acid.

Germ. Pat. 159170, describes the preparation of fatty acids from faeces (see "FATS AND OILS").

According to Germ. Pat. 172690 the conversion of oleic acid into solid acids can be accomplished in the following way. Formaldehyde in certain proportions is added and an emulsion made. Zinc dust is introduced and the whole treated with hot water (not above 80°). The zinc sinks to the bottom and the acids collect on the surface as a liquid which readily solidifies to a mass of fatty acid (softens at 50° , melts at 68°).

Fatty acid apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Fatty acid Distillation:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Fat splitting apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Fayence see "STONE WARE."

Feather-alum = ASBESTOS (q. v.).

Feather Alum:

Aflenzler Grafit- und Talksteingewerkschaft G. m. b. H.

Feather white = ASBESTOS (q. v.).

Feeding stuffs. Only those are mentioned here which are waste products obtained in some industry.

1. **WASH** (distiller's; vinasse). The residue of fermented mash after the alcohol is distilled off. According to the source a distinction is made between potato and grain vinasse. Both are used as a good forcing food for milk producing animals; but on account of the large amount of water present it is injurious to health and affects the quality of the milk if the feeding is continued for too long a time. For these reasons the wash is now evaporated to dryness and ground to powder.

The composition of vinasse is shown in the following table:

	Water %	Ash %	Crude proteid %	Crude fibre %	Nitrogen- free ex- tractives %	Crude fat %
Rye vinasse, moist ...	91.10	0.50	1.90	1.00	5.20	0.30
" " dried ..	10.81	4.65	23.07	4.02	51.56	5.89
Potato vinasse, moist ..	93.30	0.50	1.20	0.70	3.50	0.20
" " dried ..	7.83	16.40	23.08	8.60	40.54	3.55

2. **BREWERS' GRAINS.** The residues obtained in Brewing (see "BEER"). They are little used in the fresh (moist) state as the water contained (about 75 %) renders the transport expensive and favours decomposition. For this reason grains are dried in special forms of apparatus.

	Water %	Ash %	Crude proteid %	Crude fibre %	Nitrogen- free ex- tractives %	Crude fat %
Brewers' grains, moist ..	75.05	4.84	6.20	0.88	11.13	1.90
" " dried ..	18.76	14.60	21.28	3.12	35.86	6.38

3. **OIL CAKES.** The residue obtained after pressing out the oil from oil-containing seeds. In addition to other nutrient materials they invariably contain more or less fat.

	Water %	Ash %	Crude proteid %	Crude fibre %	Nitrogen- free ex- tractives %	Crude fat %
Earthnut cake.....	11.15	6.22	30.65	23.46	19.47	9.05
Linseed cake	11.00	6.55	28.65	9.45	34.42	9.93
Cocoanut cake.....	10.42	4.25	16.81	24.00	35.00	9.52
Rapeseed cake	10.00	7.94	31.15	11.32	30.04	9.55
Sesame cake	9.82	10.75	37.50	6.26	21.67	14.00

4. **BET PARINGS** (Cuttings, diffusion cuttings). The beet cuttings obtained from the diffusion apparatus in sugar manufacture (q. v.). They contain much water and quickly decompose. They are made acid, or are pressed or dried.

Pressed cuttings contain about 89.8 % water, 0.9 % albumin and 6.3 % nitrogen-free extractives.

5. **MEAT FLOUR.** Made from the waste products in the manufacture of meat extracts by drying and crushing. On an average it contains 11.5 % water, 3.7 % ashes, 72.8 % crude proteid and 12 % fat. It is considered an easily digested forcing food of excellent quality.

Fehling's solution. A solution containing CuSO_4 , Rochelle salt and NaHO . Used in the estimation of sugar. For preparation &c. see VOLUMETRIC ANALYSIS.

Felspar. The common name for potassium felspar or ORTHOCLASE, a potassium aluminium silicate $[\text{K}_2\text{O} \cdot 3 \text{SiO}_2] + [\text{Al}_2\text{O}_3 + 3 \text{SiO}_2]$. Sometimes occurs in monoclinic crystals, sometimes in the form of dense masses with a granular structure. Colourless to brownish-red; transparent or opaque with a vitreous lustre.

Ordinary felspar is used in the manufacture of porcelain, as a building material and as a fertilizer.

Of less importance is the sodium felspar (sodium aluminium silicate) known as ALBITE.

Fennel, oil of. Essential oil obtained from the seeds of *Foeniculum capilla-cium* (Fennel) by distillation with water.

Colourless or yellowish oil having an aromatic odour and a sweetish, spice-like flavour. S. G. (15°) 0.920 to 0.980. Solidifies to a crystalline mass at 10° (α) $D = +7^\circ$ to 22° . It contains pinene, dipentene, fenchone and anethol (the chief constituent of aniseed). It is slightly soluble in water, much more readily in alcohol. It is used in medicine and in the manufacture of liqueurs and soaps.

Fermangol. The trade name for a remedy for chlorosis and nervous complaints. According to AUFRECHT it is an aqueous-alcoholic, aromatic solution, containing about 5 % iron manganese saccharate, 1.5 % calcium glycerine phosphate with 14 % cane sugar and 14.2 vol. % alcohol.

Ferments. Unorganized ferments or enzymes are bodies closely related to the proteids but otherwise little is known concerning them. Extremely small quantities are able to change very large quantities of organic matter. All fermentative processes consist of a splitting, i. e. complex compounds are split into simpler ones, a process which usually consists of hydration.

The most important enzymes are: 1. DIASTASES, liquefying starch and converting it into sugar (one of these is the ptyaline of the saliva); 2. ZYMASES, causing alcoholic fermentation, i. e. splitting sugar into alcohol and carbonic acid; 3. PEPSINE occurring in the secretion of the stomach, converting albumens into peptones; 4. TRYPSINE which has an action similar to pepsine; 5. LIPASE, splitting fats; 6. INVERTASE, changing cane sugar to invert sugar; 7. GLYCASE or MALTASE, forming grape sugar from maltose; 8. MELIBIASE, splitting raffinose into the simpler sugars; 9. CATALASE splitting H_2O_2 into H_2O and O ; 10. RENNET, curdling milk; 11. OXYDASES carrying atmospheric oxygen to oxidizable bodies.

Fernambuco wood (Lignum Fernambuci; Lignum brasiliense), also called Brazil wood, Nicaragua wood, Pernambuco wood and Red wood. It is the trunk wood of *Caesalpinia echinata*. Further details will be found under "VEGETABLE DYES".

Ferratine. A compound of iron and albumen in which the iron is firmly held. It is formed according to Germ. Pat. 72168 and 74533 by treating egg albumen with ferric tartrate. It is a reddish brown, insoluble powder, easily digested, and is an agreeable iron preparation.

Ferratogen. Iron nuclein compound containing 1 % Fe. Brownish insoluble powder, used medicinally. Easily absorbed by the intestines.

Ferratose. A solution of Ferratine (see above) containing 0.3 % Fe in an easily absorbed form. It is similar to ferratine in action and properties.

Other elements combined with the organic substance can be introduced into ferratine, e. g. I and As, giving Iodine-ferratine and Arsenic-ferratine respectively. Both are usually prepared as solutions and are prescribed as Iodine-ferratose and Arsenic-ferratose. Each contains 0.3 % Fe, the former 0.3 % I, and the latter .003 % As in addition.

Ferrhaemine(-HERTEL). Compound of fresh ox-blood with iron, 20 % wine being added as a preservative.

Ferric compounds and Ferrous compounds see "IRON COMPOUNDS".

Ferrichthol = FERRUM SULFOICHTHYOLICUM.

Brownish-black insoluble powder odourless and tasteless, used medicinally as an iron preparation, containing 3.5 % Fe and 96.5 % ichthyl-sulphonic acid.

Ferripyrine see "FERROPYRINE".

Ferroaluminium see "IRON ALLOYS" No. 1.

Ferrochromium see "IRON ALLOYS" No. 3.

Ferrocyanides see "IRON COMPOUNDS" No. 14.

Ferrocyanogen blue see "IRON COLOURS".

Ferromanganese see "IRON ALLOYS" No. 4.

Ferromolybdenum see "IRON ALLOYS" No. 5.

Ferronickel see "IRON ALLOYS" No. 10.

Ferropyrine (FERROPYRINE). Compound of antipyrin with ferric chloride. Taken internally as a remedy for chlorosis, neuralgia, sick-headache, and intestinal bleeding.

Ferrosilicon see "IRON ALLOYS" No. 6.

Ferrostyptine. Double salt of hexa-methylene-tetramine-chloride and ferric chloride $(\text{CH}_2)_6\text{N}_4 \cdot \text{HCl} \cdot \text{FeCl}_3$.

Yellow, very soluble powder, with an astringent taste. Used as an astringent and astringent in 20 to 40 % solution.

Ferrostyptine:

Dr. C. L. Marquart, chem. Fabrik Beuel a. Rhein (Germany).

Ferrotitanium see "IRON ALLOYS" No. 7.

Ferrotungsten see "IRON ALLOYS" No. 13 and "TUNGSTEN ALLOYS".

Ferrovanadium see "IRON ALLOYS" No. 18.

Fersan. A para-nucleine-compound containing iron. Besides containing a large percentage (90 %) of albumen in a soluble and easily absorbed form (acidalbumin). It is characterized by its contents of iron and phosphorus (combined in an organic form), it is thus an iron preparation and at the same time a food.

Fervine. Meat extract combined with iron compounds.

Blücher.

Festoform. A solid preparation of formaldehyde obtained by mixing an aqueous solution of formaldehyde with small quantities of a soda soap solution; it is prepared in tablets, pastilles, and as an amorphous mass. The formaldehyde contained is not polymerized, the substance is very stable and should find use as an antiseptic, disinfectant and de-odouriser. A special kind of festoform is recommended for the disinfection of closed rooms.

Fetron. A new ointment basis, introduced by Professor LIEBREICH to replace vaseline and Ungt. Paraffini. Fetron is a mixture of best yellow vaseline and pure anilide of stearic acid, of a yellow colour, M. P. 68°. It mixes with all drugs, never becomes rancid, has good covering properties and is easily removed from the skin.

Fibroin see SILK.

Fibrollysine. A double salt of thiosinamine (q. v.) and sodium salicylate. It is soluble in water and the solution is valuable on account of its property of softening scars, wounds, &c. It is sold in the form of a sterilized solution in glass bulbs containing 2.3 ccm fibrollysine solution (equal to 0.2 g thiosinamine).

Fillite see "GUNPOWDER".

Filmarone. A substance present to the extent of 5 % in fern roots. The active principle is a specific against worms.

Pure filmarone has acidic characters. It is a straw-yellow amorphous powder M. P. 60°, easily soluble in most organic solvents, with difficulty in methyl alcohol, almost insoluble in H₂O.

According to the age of the patient the dose varies from 0.3—1 g. Usually it is sold as a 10 % solution in castor oil, a preparation known as filmarone oil.

Filters.

Filters and Filtering apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO 16, Brückenstr. 6b (see advta.).

Filtercloth.

Filtercloth:

C. Harzer & Co., Finsbury Pavement House London E.C.

Filter presses. A filter press consists of a series of boxes between two strong head-pieces, one movable and one fixed (the latter on stand), resting on two strong side spindles and lined with some suitable filtering material. They receive the liquid to be filtered (which flows into all the boxes) by a side tube which runs through the whole series. The pressure exerted by a pump causes the clear liquid to pass through the meshes of the material and to escape by the channels made in the box plates for this purpose while the solid substances remain in the boxes between the cloths. The solid substances obtained can be washed in the press itself, either to purify them or to obtain the soluble substances clinging to them. A distinction is made between Box Presses in which the smooth rim surrounding the filter surface of the plates is raised, so that two adjoining plates make a box, and Frame Presses in which the closing rim is in a plane with the filter surface and where the boxes are formed by intercalated hollow frames. The filter presses are generally made of wood or iron. In iron presses, in order to protect the filter cloth, the filtering surfaces are covered with a finely corrugated or perforated iron sheet. In box presses

where the cloths are fixed to the delivery tube by cloth screws the plates are completely covered with cloth. The arrangement is cloth against cloth and the residual substances for which an outlet is provided fall out at the bottom when the plates are separated. The cloths of frame presses are only hung over the frames, and the arrangement is cloth against iron or wood, so that the residues are lifted out of the press with the frames. The presses are closed with mounted closing spindles, bolt spindles or by angular lever spindles. Recently filter presses with slides of stone ware have become more general.

Filterpresses:

C. Harzer & Co., Finsbury Pavement House London E.C.
Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Filter stones. Porous acid proof artificial filter stones of finer or coarser grain. They have recently been used for suction (vacuum filters) in separating acid liquids from precipitates. Also used for the filtration of acids, &c. For a long time a great disadvantage was experienced in that the requisite uniformity could not be obtained simultaneously with a fine porous structure; fine porous stones of greater thickness cannot be produced uniformly, while on the other hand thin stones cannot stand great pressure due to suction.

An invention (patent applied for) by W. SCHULER evades this difficulty by letting the porous stone consist mainly of coarsely porous material with a surface of finer material varying from 2—10 mm in thickness, so that without increasing the time of filtering solid substances are absolutely prevented from entering the interior of the stones. The under surface of the stones is provided with perforations, channels, &c. in the coarser material.

The usual dimensions of the porous stones are 20 × 20 cm with a thickness of 5 cm, though larger forms are made. The connections between the individual plates are usually made with asbestos cord.

Sucking filters of Earthenware:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Fireproof, rendering articles. The following substances, amongst others are used to lessen the inflammability of certain articles.

1. Ammonium Sulphate or Ammonium Phosphate 6 to 10 % solution.
2. 8 ammonium sulphate, 2.5 ammonium carbonate, 3 boric acid, 2 borax, 2 starch in 100 H₂O.
3. 20 % solution of sodium tungstate mixed with 4 % sodium phosphate.
4. 1 sodium tungstate, 6 alum, 2 borax, 1 dextrine in 100 soap solution.
5. 6 borax, 5 magnesium sulphate, 1 starch in 50 H₂O.
6. 15 sal-ammoniac, 5 boric acid, 50 glue and 1 gelatine in 100 H₂O mixed with enough lime to yield a mixture that can be applied with a brush at 50—60° C. (for stage scenes, wood, &c.).
7. Waterglass solution mixed with chalk or glass powder (for painting wood).
8. Impregnation for same purpose with iron vitriol, borax, &c.
9. 10 barium sulphate, 5 sodium tungstate, 20 starch boiled in H₂O (for textiles).
10. 20 borax, 20 sodium tungstate, 60 starch boiled in H₂O (used like 9).
11. Equal parts zinc sulphate, magnesium sulphate and sal-ammoniac are mixed with three times the weight of ammonia alum. The mixture is a damp-mass which is dried at moderate heat. For textiles 2 parts starch are mixed with one part of the fire proofing material.
12. Painting with asbestos paint.
13. According to Germ. Pat. 138807 a solution of 10—20 parts potassium carbonate and 4—8 parts ammonium borate in 100 parts water is

applied. On heating a glassy mass is formed which is fire-proof; at the same time CO_2 is set free which extinguishes the flames.

14. According to Germ. Pat. 150465 the material is soaked in a solution of sodium stannate (22° Bé) dried, and treated with a zinc acetate solution (16° Bé). The material is finally dried and steamed.

15. According to Amer. Pat. 856906 cotton and linen goods are soaked in a solution of sodium stannate, dried, and then placed in a bath made of equal parts of solutions of sodium tungstate (S. G. 1.3), ammonium chloride (S. G. 1.05) and ammonia (S. G. 0.882). The goods are finally dried.

16. According to Germ. Pat. 151641 titanac acid is set free from its compounds on the textile in an insoluble form. Before applying the titanium solution the material may be treated with a sodium stannate solution. To assist the formation of titanac acid ammonium sulphate is added. The titanac acid is conveniently precipitated by a solution of sodium silicate of about 1.1 S. G. Finally the material is washed and dressed as required. See "Wood".

17. A fireproof coating is obtained, according to Danish Pat. 8991 by mixing equal quantities of sodium silicate and a 5 % solution of NaOH, treating the mixture with twice the quantity of chalk paste (or ochre) and 3 % carbolineum. The colour may be made brown by the addition of 10 % coaltar.

Fireproof Stones:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Fireproof utensils:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Fireworks (PYROTECHNICS).

a) RECIPES FOR BENGAL FIRE.

Red: 40 SrN_2O_8 , 5 KClO_4 , 13 S, 2 C.

" 24 SrN_2O_8 , 3 KClO_4 , 8 S, 8 Cu_2S , 6 Hg_2Cl_2 , 1 shellac.

" 56 SrN_2O_8 , 20 KClO_4 , 24 S.

Pink: 23 CaCl_2 , 61 KClO_4 , 16 S.

Purple red: 23 CaCO_3 , 60 KClO_4 , 16 S.

Blue: 15 copper ammonium sulphate, 28 KClO_4 , 15 S, 15 K_2SO_4 , 27 KNO_3 .

" 23 ignited alum, 61 KClO_4 , 16 S.

Green: 8 BaN_2O_8 , 3 KClO_4 , 3 S.

" 45 BaN_2O_8 , 10 KClO_4 , 10 S, 1 Sb_2S_3 .

Violet: 12 alum, 12 K_2CO_3 , 60 KClO_4 , 16 S.

Yellow: 48 NaN_2O_8 , 16 S, 4 Sb_2S_3 , 1 C.

" 23 Na_2CO_3 , 61 KClO_4 , 16 S.

White: 32 KNO_3 , 8 S, 12 Sb , 11 Pb_3O_4 (minium).

b) RECIPES FOR LIGHT-BALLS.

Red: 4 SrN_2O_8 , 3 KClO_4 , 2 milk-sugar.

" 8 SrN_2O_8 , 4 KClO_4 , 3 S, 2 Sb_2S_3 .

Blue: 5 azure blue, 12 KClO_4 , 5 S, 1 Hg_2Cl_2 .

Green: 40 BaN_2O_8 , 20 KClO_4 , 10 S, 1 shellac, 1 fine soot.

" $\frac{1}{10}$ BaCO_3 , 6 KClO_4 , 2 S.

Violet: 5 SrN_2O_8 , 4 copper filings, 5 KClO_4 , 3 S, 3 Hg_2Cl_2 .

" 1 azure blue, 4 SrN_2O_8 , 9 KClO_4 , 6 S, 1 Hg_2Cl_2 .

Yellow: 2 sodium oxalate, 4 KClO_4 , 1 shellac.

White: 9 KNO_3 , 3 S, 2 Sb_2S_3 .

" 70 KNO_3 , 14 S, 10 realgar, 12 Sb , 1 shellac.

c) RECIPES FOR "RAINS".

Most contain gunpowder.

1. 16 gunpowder, 3 C.

2. 16 " 8 KNO_3 , 3 C, 3 S, 10 fine iron filings.

3. 16 " 12 KNO_3 , 3 C, 3 S, 12 coarse iron filings.

4. 16 " 4 steel filings.

5. 16 " 8 KNO_3 , 3 S, 8 zinc filings.

6. 16 " 8 KNO_3 , 2 S, 10 copper filings.

d) RECIPES FOR EXPLOSIVE MIXTURE FOR ROCKETS.

1. 8 gunpowder, 3 coarse charcoal.
2. 16 KNO_3 , 4 S, 9 coarse charcoal.

Fish glue see "GLUE".

Fish guano see "MANURES, ARTIFICIAL".

Fixatives. To prevent fading or smearing of charcoal and chalk drawings. The drawings are subjected to the action of a fixing spray, i. e. a liquid containing a resin or similar substance dissolved in a very volatile solvent. According to Germ. Pat. 140579 a good fixing agent is obtained by adding a little waterglass to a solution of dammar resin and caoutchouc in benzene and chloroform; e. g. one part caoutchouc is used with 35 parts dammar, 3 parts chloroform and 250 parts benzene, adding if necessary another solution 35 parts dammar rosin, 3 parts chloroform and 52 parts benzene. Finally a small quantity of waterglass is added.

Flax see LINEN.

Florence flasks. Wide necked flasks used in the distillation of essential oils. An outlet tube is attached near the bottom of the flask which reaches upwards almost to the mouth of the flask and is then bent downwards. When such a flask is used as a receiver, the oil floats on the surface of the water. When the flask is nearly full of distillate, the water must escape, so that by continuing the distillation the flask eventually becomes full of oil.

Florence varnish see "COCHINEAL".

Florizine see "CASTOR OIL".

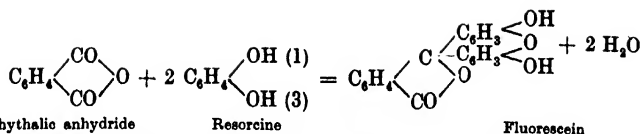
Fluid gases see "CONDENSATION OF GASES".

Fluor (FARINA). The grain is ground by horizontal, vertical or disintegrating mills. The object of milling is to remove the husk and embryo without injuring the grain itself more than is necessary. This object is only approximately achieved, because the husk is tougher and therefore ground later than the farinaceous part. This is especially the case if the grain is moistened before grinding.

In the case of horizontal mills which are especially adapted for soft grain, the grinding is carried out as finely as possible between closely adjusted millstones. The product is sifted and the residue re-ground, a process to be repeated again and again. The final product is never white because the shells have been ground during the repeated treatment. In the case of vertical mills which are especially adapted for hard grain (highly glutinous wheat) the millstones are at first set well apart. During the subsequent grinding the stones are gradually brought nearer together, and between each two grindings the product is sorted in special machines and sieves according to the degree of fineness and density. In this way a thorough separation is secured and a very fine product results, but the output is less than where horizontal mills are used. In the case of vertical mills the grain is not previously moistened.

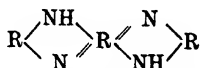
Experiments have been made recently with the object of introducing disintegrators but as to the result nothing definite can be stated.

Fluorescein. Resorcline phthaleine (tetraoxaphthalopheneanhydride). It is obtained by heating resorcline with phthalic anhydride, the action being represented by the following equation:



See also the article on "PYRONINE DYESTUFFS". Fluorescein dyes wool and silk yellow in an acid bath.

Fluoridines. Coal-tar colours which occur as intermediate products in the manufacture of Indulines (q. v.). They are diazines probably of the constitution



where R denotes aryl groups of the benzene series.

Fluorine and Fluorine compounds.

1. **FLUORINE.** F. Atomic weight = 19.1. A gas first isolated in 1886 by the electrolysis of a mixture of potassium fluoride and absolutely anhydrous hydrofluoric acid. (S. G. 1.31.) It condenses to a light yellow liquid at -185° . DWAR has succeeded in obtaining solid fluorine by surrounding it with liquid hydrogen which was allowed to evaporate. M. P. -233° . Compared with its compounds fluorine is of no importance.

2. **HYDROFLUORIC ACID.** HF. Obtained by heating CaF_2 or cryolite with concentrated sulphuric acid: $\text{CaF}_2 + \text{H}_2\text{SO}_4 = 2 \text{HF} + \text{CaSO}_4$. The reaction must take place in vessels of lead or platinum, or in iron vessels fitted with a lead cap; see **HYDROFLUOSILICIC ACID**. The distillate is collected in vessels of lead, platinum or guttapercha.

According to Germ. Pat. 142931 hydrofluoric acid can be prepared in an apparatus the construction of which is protected by Germ. Pat. 134977 (used for the preparation of acetone). A mixture (at ordinary temperature) of CaF_2 and H_2SO_4 is spread in thin layers on frames and then heated in a retort heated externally. The process is rapid and the fluor-spar is completely decomposed. At the end the frames are removed and at once replaced by fresh ones. As the retort is surrounded entirely by flames, the lead cap may be replaced by an iron one.

Anhydrous hydrofluoric acid boils at 19.4° , solidifies at -102.5° in the crystalline form and melts again at -92.5° . S. G. (at 15°) 0.9870. It fumes strongly in the air, causes blisters and sores on the skin and when breathed is extremely poisonous. It carbonizes paper, wood, cork and, except when dry, vigorously attacks glass. Paraffin is not attacked by it. Easily soluble in H_2O ; the strongly-fuming, saturated solution evolves gas when heated and leaves a hydrate $\text{HF} + 2 \text{H}_2\text{O}$ with a constant boiling point of 120° , containing about 38 % HF. The solution also has a strong action on glass so that it must be kept in vessels of Pt, Pb, guttapercha or in vessels lined with paraffin. The fluorides will be found described under the respective metals.

Fluosilicic salts:

Humann & Teisler, Dohna Bez. Dresden, Germany.

Hydrofluoric acid and Fluorine Compounds:

Humann & Teisler, Dohna Bez. Dresden, Germany.

Fluoroform. CHF_3 . Obtained by the action of silver fluoride on iodoform in presence of H_2O but in absence of oxygen.

A gas the saturated aqueous solution of which (containing 2.8 % CHF_3) is said to be prescribed internally as Aqua fluoriformii in cases of tubercular disease.

Fluorrheumine. A mixture of fluorine phenetol and difluordiphenyl in the form of ointment. Said to be used externally in cases of rheumatism, lumbago, influenza.

Fluorspar (CALCIUM FLUORIDE). CaF_2 . A mineral found in fine colourless (though frequently coloured by impurities) regular crystals. See No. 9. "CALCIUM COMPOUNDS".

According to Germ. Pat. 152194 the powdering and purification of fluorspar is effected by heating it in crucibles as rapidly as possible until it falls to a powder. The larger pieces remaining which contain the impurities are removed by sifting.

Fluorspar:

Jencquel & Hayn, Hamburg.

Fly catchers. The three following recipes are recommended:—

1. 100 parts colophony melted with 50 parts resin and 70 parts rape oil and 20 parts crude honey added.
2. 600 parts colophony, 400 parts linseed oil and 20 parts yellow wax melted together.
3. 500 parts brown colophony, 250 parts castor oil are melted and then 50 parts glycerine are stirred in. Finally 100 parts crude honey are added.

Fomitine. A liquid extract prepared in the cold from the fungi *Fomes cinnamomeus* and *F. igniarius*, parasitic on the members of the genus *Prunus*.

Fomitine is used medicinally in cases of diseases of the bladder, irregularities in menstruation and haemorrhoids.

It is a clear reddish-brown liquid.

Foods, prepared. See PROTEIDS, MEAT PREPARATIONS, CASEINE, EUCASINE, FERSAN, HAEMOGALLOL, NUTROSE, PANCREON, PLASMON, ROBORATE, SANATOGEN, SOMATOSE, TROPON.

The following table shows the composition of certain food preparations, and the relation between price and nutritive value.

Name of preparation	Pro- teids	Fat	Carbo- hydra- tes	Water	Fibre	Ash	Units of nutri- tive value in 100g	Units of nutritive value obtained for shilling
	%	%	%	%	%	%		
Mellin's food	7.81	0.29	82.58	6.15	—	3.17	122.5	189
Nestle's food	9.94	4.53	77.45	6.01	—	1.75	140.5	401
Kufeke's food	13.24	1.69	73.88	8.37	—	2.23	145.0	414
Bodin's acorn-oatmeal ...	13.25	4.35	67.96	10.50	2.04	1.90	147.5	738
Vermicelli (Klopfer)	15.54	0.69	74.78	7.15	—	1.84	154.5	1717
Butter biscuit (Klopfer) ..	10.30	9.20	76.80	2.80	—	0.87	156.0	1013
Rademann's food	14.15	5.58	70.03	5.58	—	3.93	157.5	525
Oatmeal (Knorr)	13.71	8.67	66.71	9.12	—	1.74	161.5	1615
Klopfer's food	18.90	3.36	72.95	2.40	—	2.37	177.5	355
Heyden's food	79.62	0.10	—	7.96	—	4.75	399.0	93
Somatose	81.50	—	—	10.04	—	6.72	407.5	82
Nutrose	82.18	0.41	—	10.97	—	3.63	412.5	187
Sanatogen	82.70	0.80	—	9.22	—	7.26	416.0	130
Tropen	88.76	0.34	—	9.77	—	1.13	445.0	742

Foods	Pro- teids	Fat	Carbo- hydra- tes	Water	Fibre	Ash	Units nutri- tive value per 100 g	No. of units of nutritive value ob- tained for one shilling
	%	%	%	%	%	%		
Fine wheat bread	7.06	0.46	56.58	35.59	0.32	1.09	93.5	2220
Eggs	12.55	12.11	0.55	73.67	—	1.12	99.5	580
Veal liver	17.66	2.39	5.47	72.80	—	1.68	101.0	2910
Lean veal	19.86	0.82	—	78.84	—	0.50	102.0	615
Lean beef	20.71	1.74	—	76.37	—	1.18	109.0	620
Pigeons	22.14	1.00	0.76	75.10	—	1.00	114.5	635
Rice	6.73	0.88	78.48	12.58	0.51	0.82	115.0	1915
Barley	7.25	1.15	76.19	12.82	1.36	1.23	116.0	2650
Fat veal	18.88	7.41	0.07	72.31	—	1.33	116.5	730
Hare	23.34	1.13	0.19	74.16	—	1.18	120.5	500
Lean pork	20.25	6.81	—	72.57	—	1.10	121.5	870
Fat fowl	18.49	9.34	1.20	70.06	—	0.91	121.5	500
Maccaroni	9.02	0.30	76.77	13.07	—	0.84	123.0	1535
Smoked herrings	21.12	8.51	—	69.49	—	1.24	131.0	770
Preserved beans (French)	18.36	1.54	45.20	20.66	9.46	4.78	141.5	260
Biscuits	11.00	4.60	73.30	9.60	—	1.50	142.0	300
Herrings	18.90	16.89	1.57	46.23	—	16.41	146.5	1400
German biscuits	11.93	7.47	68.67	10.07	0.75	1.14	150.5	380
Sausage (liver)	15.93	26.33	6.38	48.70	—	2.66	165.0	1030
Fat mutton	16.62	28.61	0.54	53.31	—	0.93	169.5	1115
Fat beef	16.75	29.28	—	53.05	—	0.92	171.5	1020
Peas	23.15	1.89	52.68	13.92	5.68	2.68	174.0	5800
Smoked Beef	27.10	15.35	—	47.68	—	10.59	181.5	570
Beans (field)	25.31	1.68	48.33	13.49	8.06	3.13	184.0	6140
Fat pork	14.54	37.34	—	47.40	—	0.72	184.5	1200
Lentils	25.94	1.93	52.84	12.33	3.92	3.04	188.5	4620
Preserved cauliflower	29.97	3.00	30.43	21.48	8.34	6.78	189.5	230
Savely	17.64	39.76	—	37.37	—	5.44	207.5	560
Cheese	25.35	30.25	1.43	38.00	—	4.97	219.0	1150
Ham	24.74	36.45	0.16	28.11	—	10.54	233.0	770
Butter	0.74	84.39	0.62	13.59	—	0.66	257.5	1020
German sausage	27.31	39.88	5.10	20.76	—	6.95	261.5	1500

Formal see METHYLAL.

Formaldehyde (METHYLALDEHYDE, METHANAL). $\text{H} \cdot \text{COH}$. Can be prepared in many ways, as for example by passing a mixture of methyl alcohol vapour and air over a glowing platinum spiral or heated copper gauze. It is prepared on a large scale in this way, the platinum or copper being distributed in a finely divided condition over large surfaces of earthenware. The Pt and Cu act as catalytic agents. The formaldehyde is concentrated in fractionating apparatus either under the ordinary or diminished pressure. Fractionating columns are used of such form that liquid and gas come in contact with earthenware above. Certain details concerning its manufacture are preserved as trade secrets.

It is interesting to observe that formaldehyde is formed by the electrolysis of dilute methyl alcohol and also when ozone is passed through the same substance.

According to Amer. Pat. 774824 formaldehyde may be obtained by passing methane over heated ferric oxide, and according to French Pat. 352687 methane may be oxidized by hydrogen peroxide or Caro's reagent.

According to Germ. Pat. 185932 formaldehyde is prepared by passing a mixture of formic acid vapour and hydrogen over metals (e. g. Fe, Ni, Zn, Pb) or over glass, pumice, &c. at a high temperature (up to 300°).

Formaldehyde was, until recently, only known in the form of an aqueous solution or as a gas. It is now almost always obtained commercially as a 40 % solution, which contains from 12 to 15 % methyl alcohol, the presence of which prevents the separation of polymers.

Pure formaldehyde is a gas solidifying at -92° . At -20° the S. G. is 0.8513. B. P. -20.5° . It polymerizes very readily (on heating in an open vessel, for example) with formation of TRIOXYMETHYLENE (metaformaldehyde) $(\text{CH}_2\text{O})_3$ and PARAFORMALDEHYDE $(\text{CH}_2\text{O})_n$.

It is possible that paraformaldehyde and metaformaldehyde are identical, their exact constitution being unknown. They are solid crystalline substances which on heating give formaldehyde, and they are therefore used in the form of tablets or pastilles for disinfecting purposes. (These tablets are burnt in lamps of special construction and give off formaldehyde vapour). Paraformaldehyde is also used medicinally under the names TRIFORMOL and PARAFORM.

Formaldehyde is obtained in a solid form (Germ. Pat. 163323) by mixing with a small quantity of soap. The formaldehyde preparations thus obtained are free from polymeric modifications and are used as disinfectants. A similar result is obtained (English Pat. 23460 — 1902) by mixing trioxymethylene with sodium sulphite.

According to Germ. Pat. 155567 a solid derivative of formaldehyde and dextrine, soluble in water and easily powdered, can be prepared by evaporating dextrine and a solution of formaldehyde on the water bath and drying the syrupy mass *in vacuo* over some drying agent. The preparations so obtained contain 30—50 % formaldehyde and have the same chemical and physiological action as the pure substance.

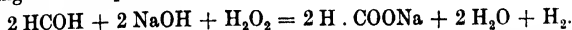
Formaldehyde, mainly in the form of paraformaldehyde is obtained (Germ. Pat. 183856) by heating tin formate to 180° . The paraformaldehyde can be obtained by sublimation.

Formaldehyde has a very pungent odour. Its vapour is a powerful disinfectant. Both in the state of vapour and in solution it is used as a preservative for meat and for the disinfection of sick-rooms. For the latter purpose, the method known as AUTAN-DISINFECTION is of great importance. AUTAN is a mixture of polymers of formaldehyde with metallic peroxides (e. g. BaO_2). The mixture to which some substance such as Na_2CO_3 is added, is made into the form of pastilles. When these are treated with water, dense fumes of formaldehyde vapour and water are evolved without any great rise of temperature. This method which is a very convenient one for disinfecting and deodourizing rooms, is protected by Germ. Pat. 178053 and French Pat. 366605. The supplement to Germ. Pat. 181509 recommends the use of perborates &c. instead of peroxides.

In addition to the above uses formaldehyde is employed to sterilize beverages, to preserve biological specimens, to harden gelatine for cotton printing, and in tanning for the rapid hardening of the hide and rendering it insoluble. Further, because of its great reactive and condensing power formaldehyde is of considerable importance in organic synthesis, more particularly in the preparation of coal-tar colours, for which purpose it is combined with aniline to form ANHYDROFORMALDEHYDEANILINE, cf. FUCHSINE. The property which formaldehyde possesses of combining with compounds of the proteids to yield completely insoluble and very stable substances, has caused it to be used for many purposes. In this way by its action on caseine, substances of a horn-like nature are obtained, and by its action on gelatine, photographic films are prepared.

TEST. The methods for the quantitative estimation of formaldehyde are very numerous. A simple one is that of BLANK and FINKENBEINER which

depends upon the oxidation of formaldehyde with H_2O_2 in alkaline solution according to the equation



To carry out this test 3 g of liquid or 1 g of solid formaldehyde are placed in a tall Erlenmeyer flask with 25 ccm of 2 N. NaOH solution. In the course of about 3 minutes 50 ccm of H_2O_2 are added, a funnel being placed in the flask to avoid loss by spurling. After 2—3 minutes the funnel is well washed with water that has been boiled and allowed to cool, and the excess of alkali back-titrated with 2 N. H_2SO_4 . 1 ccm of the alkali corresponds to 0.06 formaldehyde. It is important that the H_2O_2 used should be at least 2.5 %. The strength can be determined by titration with $\frac{1}{10}$ N KMnO_4 . The amount of free HCl or H_2SO_4 must be previously determined and the amount found taken into account in the calculation.

For the estimation of methyl alcohol in commercial formaldehyde M. STRITAR adopts the following method (Chem. Ztg. 1904, Repert. 283). 5 ccm formaldehyde solution are diluted with 100 ccm H_2O , treated with an excess of NH_3 (generally 10 ccm of 12 % NH_3 are sufficient) and the mixture distilled. 50 ccm of the distillate are collected in a 100 ccm flask, acidified with acetic acid and made up to 100 ccm. In 5 ccm of this solution, which contains only traces of formaldehyde, the methyl alcohol is estimated by the iodide method. It has been shown that traces of formaldehyde have no effect on the result obtained.

Formic aldehyde (Formaldehyde):

Hugo Blank, Berlin W. 35.

Formaldehyde gelatine see "GLUTOL".

Formaldehyde soaps. Soft soaps obtained by mixing formaldehyde with oils, or hard soaps, prepared from formaldehyde with soda or potash soaps.

Formaline see "FORMALDEHYDE".

Formaline sapene (cf. SAPENE) is employed in 10—20 % solution as a remedy for perspiring feet, and in 3—5 % solution as a preventive of the night-sweats of tuberculosis.

Formaline soaps (Name protected in Germany. No. 52607 and 60138). Put on the market as liquid, solid or semi-solid, and as formaline cream.

LIQUID FORMALINE SOAP is a mixture of olive oil, alcohol, and essential oils with 10—25 % liquid formaldehyde (formaline).

SOLID FORMALINE SOAP consists of neutral soap, 5 % paraformaldehyde and perfume; it is prepared by grinding and mixing in pill machines.

The soft formaline potash soap is prepared from linseed oil and KOH by adding 10 % liquid formaldehyde; powdered formaline soap by adding 5 % formaldehyde to neutral soap-powder; and formaline cream by adding 10 % liquid formaline to lanoline.

Formamint. A compound of formaldehyde and milk sugar. It is used in the form of tablets (each containing 0.01 g formaldehyde) as a remedy in cases of disease of the mouth and throat, as a mouth-disinfectant, and as a preventive of infection (the tablet is allowed to dissolve slowly in the mouth). The action of gargles is intensified by the addition of formamint.

Forman. Chlormethylmenthylether. Prescribed as a remedy for colds.

Formates see "FORMIC ACID".

Formic acid. $\text{H} \cdot \text{CO}_2\text{H}$. Occurs naturally in ants, certain caterpillars, pine-needles and the stinging hairs of nettles. It is not as a rule prepared from these substances (by distillation with water) but is synthetically obtained. Crystallized oxalic acid is heated under a reflux condenser with anhydrous glycerine, and the resulting formic acid removed by distillation. Recently sodium formate has been prepared by the GOLDSCHMIDT-method, i. e. by the action of CO (producer gas) on powdered caustic soda. The cost of production by this method is so low, that now oxalates (see OXALIC ACID) can be prepared from the formates, whereas before the formates were prepared from the oxalates. An improvement is described in the French Pat. 342168: NaOH solution is introduced into a vessel filled with coke and CO is blown through the mixture at 200° , or Na_2CO_3 solution at 220° is used and the CO blown through for a longer time. In place of Na_2CO_3 , Na_2SO_4 may be used. For the preparation of calcium formate milk of lime is used, but in this case a higher temperature is necessary — 250° . French Pat. 367088, an improvement on Germ. Pat. 86419, consists in carrying out the process in presence of definite quantities of water. The NaOH need not be in the form of powder or solution (according to Germ. Pat. 179515) but may be used in large pieces which are subjected to the action of CO at a temperature of 100 — 120° under pressure. The formate scales off from the NaOH thus exposing a fresh surface. The violent nature of the reaction makes cooling necessary.

An extraordinary method is proposed by French Pat. 352687, according to which methane is oxidized by Caro's reagent to formic acid in presence of manganic salts.

Formic acid that is almost anhydrous can be prepared from its salts (French Pat. 341764) by treating them with cooled H_2SO_4 in presence of formic acid itself. The method appears to be a good one since it was formerly possible to obtain anhydrous formic acid by the action of H_2SO_4 on formates with repeated distillation over H_2SO_4 . In this way a considerable amount of the acid was destroyed. A similar method is proposed by Germ. Pat. 169730 in which the formate is dissolved in conc. formic acid and then heated with conc. H_2SO_4 . The formic acid as solvent may be replaced by conc. acetic acid, and the conc. H_2SO_4 by acid sulphates (supplements to Germ. Pat. 182691 and 182776). French Pat. 367316 is similar to the last-named.

Formic acid is a mobile transparent liquid which solidifies on cooling. M. P. 8.6° . B. P. 99° . S. G. 1.223 (at 0°). It has a pungent acid odour and produces burns and blisters on the skin. Formic esters are obtained from sodium formate by distillation with the alcohol and H_2SO_4 .

TEST. The acid is titrated in aqueous solution with NaOH (phenolphthaleine as indicator). HCl and oxalic acid are tested for by means of AgNO_3 . After saturation with NH_3 the solution should show no change on the addition of CaCl_2 solution. Acroleine and allyl alcohol are tested for by neutralizing with NaOH, after which no pungent or acid smell should be noticeable.

Formic Acid:

C. Erdmann, Leipzig-Lindenau.
Heymann, Gaismann & Co., Bradford.

Formicine (Formaldehydeacetamide) $\text{CH}_3 \cdot \text{C} \begin{array}{l} \text{NH} \\ \diagup \\ \text{O} \cdot \text{CH}_2 \cdot \text{OH} \end{array}$ is prepared

(Germ. Pat. 164610) by the action of formaldehyde on acetamide. It occurs as a colourless syrupy liquid. It has an antiseptic action and is used chiefly, in varying concentrations, for injections in tuberculous regions, as a disinfectant for wounds and in antiseptic surgery generally.

Formine see "HEXAMETHYLENETETRAMINE".

Formobor. Aqueous 4 % solution of formaldehyde and 1.5 % borax. Recommended as a disinfectant, particularly for articles used in hair dressing, &c.

Formurol. A compound or mixture of hexamethylenetetramine and sodium citrate. It is a white powder soluble in water with a pleasant taste. Administered in doses of 1 g several times daily in cases of gout and urinary trouble.

Formysole. A disinfectant related to lysoform (see special article). It is a glycerine potash soap with an addition of 10—25 % formaldehyde.

Fortoin. Obtained by the action of formaldehyde on cotoine (active principle of coto bark); prescribed internally in cases of diarrhoea. Its effect is especially beneficial when used in chronic catarrh of the bowels.

Fossil meal see INFUSORIAL EARTH.

Fossil resins see "RESINS, FOSSIL".

Fractionating apparatus see "DISTILLATION", "RECTIFICATION".

Fractionating apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO 16, Brückenstr. 6b (see advts.).

Frankfort black. A paint valuable for its covering properties; used also in copper printing processes. The finest kinds are obtained by carbonising wine yeast, medium kinds by carbonising and extracting wine residues, inferior kinds by mixing better qualities with charcoal, soot, &c.

Freezing mixtures see "ICE".

Frostine preparations. Mixtures containing bromocoll (q. v.) used externally for chilblains, &c. **FROSTINE BALSAM** is a solution of 1 part bromocoll in 10 parts collodion with the addition of 1 part alcohol and $\frac{1}{2}$ part tincture of benzoin. **FROSTINE SALVE** is a 10 % bromocoll resorbin ointment.

Fruit essences. Dilute alcoholic solutions of different esters the aromas of which resemble those of various fruits. They are chiefly used in confectionery and the manufacture of liqueurs; the most important constituents are the following:

Ethyl nitrate, acetic ester, butyric ester, benzoic ester, amyl nitrite, amyl acetate, amyl valerate, amyl caproate, methyl benzoate (niobe oil) and methyl salicylate (oil of wintergreen).

The compositions of the most common fruit essences are:

1. **APPLE.** 50 g ethyl nitrate, 50 g ethyl acetate, 100 g amyl valerate, 40 g glycerine, 7.5 g aldehyde, 7.5 g chloroform, 745 g alcohol.
2. **APRICOT.** 35 g benzaldehyde, 190 g amyl butyrate, 10 g chloroform, 765 g alcohol.
3. **CHERRY.** 15 g amyl acetate, 8 g amyl butyrate, 10 g benzaldehyde, 2 g oil of cinnamon, 2 g oil of lemon, 2 g oil of cloves, 1 g oil of sweet orange; 960 g alcohol.
4. **PEACH.** 100 g amyl valerate, 100 g amyl butyrate, 20 g ethyl acetate, 10 g benzaldehyde, 770 g alcohol.
5. **PEAR.** 200 g amyl acetate, 50 g ethyl acetate, 100 g ethyl nitrate, 20 g glycerine, 630 g alcohol.
6. **PINEAPPLE.** 25 g ethyl butyrate, 135 g amyl valerate, 5 g chloroform, 5 g aldehyde, 830 g alcohol.

7. RASPBERRY. 60 g pear essence, 15 g chloroform, 9 g ethyl acetate, 6 drops oil of roses, 2 drops oil of cinnamon, 2 drops Portuguese oil, 100 g essence of violets, 600 g raspberry essence, 216 g alcohol.

8. STRAWBERRY. 27 g amyl acetate, 18 g amyl valerate, 9 g amyl butyrate, 9 g amyl formate, 15 g ethyl acetate, 7 g essence of violets, 915 g alcohol.

Fruit juice. A new method is protected by Germ. Pat. 153561. The fresh coloured fruit is after crushing well covered and allowed to stand in a warm room for 24 hours, when it is pressed. The expressed juice is sterilized by steam at 90—95° and then filtered. In order to introduce the juice into the sterilizer and also to suck it through the filter a vacuum apparatus is employed. The filtered juice is placed in vessels for transport, without the admission of air. In case of colourless fruits the pressing is performed at once, without preliminary standing in the warm chamber.

According to Germ. Pat. 184760 the aromatic constituents may be extracted by chloroform. The solvent is distilled off *in vacuo*, and the residue purified with alcohol.

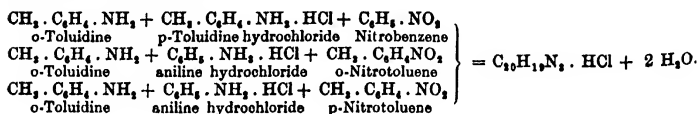
Cf. TEMPERANCE BEVERAGES and LEMON JUICE.

Fruit sugar. Formerly no cheap process of obtaining fruit sugar was known. It can be prepared however (Germ. Pat. 143540) from INULINE which occurs in considerable quantities in the roots of chicory (*Cichorium*) and other plants. The method is not new, but the present process avoids the isolation of the inuline (an expensive operation) and directly converts the plant juice or an aqueous extract into fruit sugar. The washed and finely-divided roots of the chicory are mixed with luke-warm water, and heated in a boiler fitted with stirring apparatus to 60—70°. This treatment is repeated three or four times until the residue contains no inuline. The aqueous extract is acidified with dilute HCl and quickly heated to 80° in order to separate the proteid and pectine substances. In the hot filtrate the inuline is converted into laevulose by treatment with HCl.

When quite cold the solution is heated with pure powdered quicklime. The calcium compound of laevulose is precipitated while the corresponding dextrose compound remains in solution. The excess of CaO is converted into CaCl₂ which also dissolves. From the washed and purified calcium compound pure laevulose is obtained.

Fuchsine (RUBY, MAGENTA, AZALEINE, ANILINE RED, &c.). This is a mixture of the salts of rosaniline (triparaamidodiphenyltolylcarbinol) and pararosaniline (triparaamidotriphenylcarbinol). The commercial article generally consists of the hydrochlorides, but the acetates, nitrates and sulphates are also used. It is usually prepared from "Red oil" or "Aniline oil for red" (see "ANILINE") which is a mixture of 1 part aniline with 2 parts toluidine (approximately). The conversion of red oil to fuchsine was formerly carried out only with arsenic acid. At present, however, this process is almost entirely abandoned because of the arsenic contained in the product. Nitrobenzene and formaldehyde have taken the place of arsenic acid.

In the nitrobenzene process the red oil is first partly or completely converted into hydrochloride. The oxidizing agent is nitrobenzene or a mixture of nitrobenzene and nitrotoluene: metallic iron or ferrous chloride serve as carriers of oxygen. The action is represented by the following equation, though the details are uncertain:



In one operation 300—1200 kg red oil are used; $\frac{1}{3}$ of it is mixed with the nitro mixture while the other $\frac{2}{3}$ of the red oil are exactly neutralized with HCl, evaporated and then put into in a closed vessel with a stirring apparatus. Heat is applied, Fe (or FeCl_2) added, the lid is fitted and more heat applied. The actual fuchsine melting takes place at about 160° and a vivid bronze green tone appears. The crude fuchsine obtained is broken up and extracted with H_2O . The filtrate is put into large vats with common salt when the fuchsine is precipitated. It is purified by repeated crystallisation from water with addition of HCl.

Various by-products are formed in the fuchsine process; and in this respect the formaldehyde process appears to be of greater value. From aniline and formaldehyde first anhydroformaldehydeaniline, $\text{C}_6\text{H}_5 \cdot \text{N} : \text{CH}_2$ is formed which is transformed to diamidodiphenylmethane by heating with aniline and aniline salts. By oxidising this product together with aniline or one of its homologues fuchsine is formed.

By sulphonating fuchsine or rosaniline with fuming H_2SO_4 or chloresulphonic acid, acid fuchsine (acid ruby, fuchsine S, ruby S) is formed, which is sold in the form of its acid salts.

Quite recently fuchsine has also been obtained electrochemically, by electrolytically reducing the corresponding nitro leuco-derivatives of the triphenylmethane series in presence of acids, clay diaphragms being used. The essential condition for the success of the reaction is that the nitro group must be in the para position to the methane group.

Wool is dyed with fuchsine in neutral or soap baths, silk in slightly acid boiled-off baths and cotton on tannin-antimony mordant, on tannin-tin-salt mordant, more rarely on oil-alumina mordant; with acid fuchsine silk and wool are dyed in acid baths.

Fucole. The trade name for a preparation of iodine-containing sea-weeds which are broken up, roasted until they can be easily powdered and then mixed with sesame oil. It is suggested as a substitute for cod-liver oil. It contains, however, only a trace of iodine, is not so easy to emulsify as cod-liver oil, and on the whole is very similar to sesame oil.

Fuel. The solid fuels are wood, charcoal, peat, brown coal (lignite), and coal. Under coal are included briquettes. Petroleum is the only liquid fuel used to any extent.

Amongst gaseous fuels may be mentioned coal gas, oil gas, wood gas, producer gas, water gas, and acetylene.

Electricity as a heating agent holds a position quite apart from the above mentioned substances.

Solid fuels still retain the dominant place, and of these coal and brown coal are the most important. Heating by coal gas is really only another method of heating with coal. The amount of heat generated while burning determines the value of a material as a fuel. The essential constituents of all fuels are carbon and hydrogen. The products of combustion are H_2O and CO_2 . In determining the heat a distinction must be made between the amount of heat developed from the fuel (total heat, power of combustion and absolute heating effect) and the temperature which the fuel attains, by assuming that the initial temperature is 0° .

The amount of heat liberated is less when instead of the ultimate products of combustion given above, an intermediate product is formed, that is when from C only CO is formed instead of CO_2 or when CO_2 is formed from CO. On the other hand, the heat evolved by burning is always the same when passing into another combination whether the latter results in one process or whether it takes place in several phases. By heat of combustion or absolute heating effect is understood, not the entire amount of heat developed during

the process of combustion, but only that part which appears as free heat, the remainder being itself used in the process of combustion.

Whilst the carbon and hydrogen in the fuel by their oxidation give rise to a development of heat, the oxygen and nitrogen present are, on the contrary, detrimental, the nitrogen simply as an inactive agent, the oxygen because of its combination with so large a part of the hydrogen of the fuel which would otherwise evolve heat (heat of formation). Further the value of a fuel is influenced by the amount of hygroscopic water, present since this requires heat for its evaporation. Finally also the processes of reduction which occur under certain conditions lower the value of the fuel. The combustion of C to CO and then of CO to CO₂ is an exothermic process, that is one in which heat is developed, whilst the reduction of CO₂ to CO is endothermic, that is, heat is absorbed during the process. The unit of heat — a calorie — is that amount of heat necessary to raise the temperature of 1 kg of H₂O from 0° to 1°.

The following are the most important values:

1 kg C on burning to CO gives.....	2437	Heat units.
" " " CO ₂ "	8080	" "
1 kg CO on burning to CO ₂ gives	2403	" "
1 kg H converted into steam	29100	" "
" " " water	34500	" "

To calculate the heat of combustion of a fuel, DULONG recommends an elementary analysis of the material. If analysis shows the presence of C % carbon, H % hydrogen and O % oxygen, the heat of combustion, C, of the material (assuming that the hydrogen is converted into liquid water) is:

$$C = \frac{8080 C + 34500 \left(H - \frac{O}{8} \right)}{100}$$

If however the hydrogen is converted into steam the formula is as follows:

$$C = \frac{8080 C + 29100 \left(H - \frac{O}{8} \right)}{100}$$

DULONG's determination is in practical use more especially for the calculation of the heat of combustion of coal. By taking into account the contents of S (which is always present to some extent) and the amount of heat necessary to evaporate the hygroscopic water, W, which (is 652 heat units) the result will be in round numbers the general formula employed for the calculation of the theoretical heating effect of coal:

$$C = \frac{8000 C + 29000 \left(H - \frac{O}{8} \right) + 2500 S - 600 W}{100}$$

For the exact determination of the absolute heating effect, a direct estimation is made with a calorimeter. See CALORIMETRY. Concerning the solid fuels, the following remarks may be added.

WOOD. As the result of a great number of separate analyses, the average composition of the common kinds of wood has been shown to be as follows:

	C	H	O	ash	H ₂ O
Wood, air-dried	36.6	4.8	34.8	0.8	20 t
" free from water	49.5	6.0	43.5	1.0	—
" " " " and ash	50.0	6.0	44.0	—	—

The calorific power of wood with 20 % water is taken as 2800 heat units.

PEAT. The average composition of peat (after removal of earthy substances, &c.) has been determined as 61 % C, 6 % H, and 33 % O.

The water present in fresh peat may amount to 80 %. This on air drying decreases to 25—30 %. Granting that all the O present is in the form of H_2O the following constituents can be calculated for air-dried peat after subtraction of the ash:

Carbon	45.0 %
Hydrogen	1.5 %
Water chemically combined	28.5 %
Hygroscopic water	25.0 %

The heating power of peat with 30 % of water is accepted as 3700 heat units.

Further compare the article on PEAT.

LIGNITE or BROWN COAL. A distinction is drawn between lignite, fossil wood, moor coal (earthy brown coal), and real brown coal. The elementary composition varies. DÜRRE gives the following proportions for the different varieties:

	C	H	O and N.
Fibrous brown coal (fossil bituminous wood)	57—67 %	5—5 %	37—38 %
Earthy brown coal (rotten and loose coal)	45—70 %	6—5 %	30—25 %
Conchoidal brown coal	65—75 %	6—4 %	29—21 %
Oily brown coal	70—80 %	6—8 %	24—12 %

Lignite and moor coal contain 25—30 % water and 4—10 % of ash. The calorific power is 3000—3500 units. In a very dry condition brown coal still contains 10—20 % water and 4—10 % of ash. The calorific power amounts on an average to 5000 heat units.

BROWN COAL BRIQUETTES see BRIQUETTES.

These have about the same calorific power as medium brown coal.

COAL. From the appearance of the coke produced, SCHONBORFF distinguishes five kinds of coal.

The surface of the coke cake produced in the platinum crucible shows:

Rough	} loose throughout or at least up to the edges	I. Sandy coals.
sandy, fine		
black		
	} loose only in the middle	II. Slagged non-caking coal.
	coked throughout	III. Slag coal.
Grey and firm, "opening out"	IV. Slag forge coal.	
Smooth and firm with a metallic lustre	V. Smith or fat coal.	

Of these groups number V is specially adapted for making coke and gas and for use in smelting. For gas manufacture a coal would be chosen giving the least possible amount of coke, while for smiths' fires and for making coke that yielding the largest amount of coke is desirable. Bituminous coal can also be used for the above purposes but not to the same advantage. The coals belonging to group IV and V have the peculiarity of swelling and puffing up in very varying degrees. The coals of the first groups are only fit for steam-boilers, reverberatory furnaces, and for domestic use.

Average composition of the most important kinds of coal.

Situation of mines	C	H	O	N and S	Ash	H_2O in air-dried coal
Upper Silesia.....	76.81	5.10	9.14	0.79	6.57	4.40
Saxony	77.88	4.27	11.30	0.92	5.36	6.18
British bituminous coal	79.71	5.25	10.38	2.90	2.12	—
Other bituminous coals.....	83.06	5.10	7.19	—	4.09	—
British non-caking coal.....	81.57	4.89	8.16	1.24	1.13	0.73
Other non-caking coal.....	83.37	4.53	8.60	—	4.14	—
Cannel coal	80.73	5.68	6.55	1.92	4.68	—
Anthracite	90.19	2.82	2.14	0.99	2.53	—

Blücher.

The calorific power of medium coal is calculated as about 7500 units. That of anthracite amounts to about 8100 heat units.

COKE. Details of manufacture see COKE.

The compositions of the different kinds of coke vary greatly.

Place of manufacture	C	H	O	S	Ash
GERMANY:					
Westphalia	83.49—91.77	0.74—1.26	0.04—7.66	6.40—10.31	
Saar	88.46	1.98	3.02	8.54	
ENGLAND:					
Durham	84.36—93.15	0.19—0.72	0.30—7.30	0.70—9.15	
AMERICA:					
Pennsylvania	84.73—89.58	0.10—0.33	0.46—1.38	0.82—2.11	9.11—13.35
Ohio	90.63—93.75	—	—	0.27—0.87	5.38— 8.38
Alabama	84.04—88.22	0.36—0.68	0.66—0.99	0.45—0.56	11.32—15.22
BELGIUM:					
Seraing	80.85	0.51	2.13	16.51	
Mons basin	91.30—91.59	0.33—0.47	2.05—2.17	—	5.89— 6.20
AUSTRALIA:					
New South Wales ..	84.21—90.88	0.31—0.69	0.33—0.53	0.42—0.59	7.93—14.05

The amount of hygroscopic water in the different kinds of coke varies, after storing under cover, from 5 to 10 %, and increases in damp surroundings to 18 or even over 20 %. The calorific power of coke with an ash content of 15 % is calculated as 6800 heat units. Cokes with less H_2O evolve more heat.

As a means of comparing the different fuels, the following table shows the absolute heating effect of the various kinds mentioned.

Perfectly dry wood	3750 H. U.	Petroleum residues	11020 H. U.
Air-dried wood	2900 “	Hydrogen	29100 “
Charcoal	7500 “	Methane	12700 “
Perfectly dry peat	5000 “	Ethylene	11100 “
Air-dried peat	3600 “	Coal gas	10600 “
Peat charcoal	6500 “	Blast furnace gases	1070 “
Brown coal	6400 “	Carbon monoxide	2403 “
Dry coal	6900 “	Alcohol	7183 “
Ordinary coal	8100 “	Ether	9027 “
Bituminous coal	8300 “	Methyl alcohol	5310 “
Anthracite	8000 “	Turpentine oil	10850 “
Coke	7100 “	Sulphur	2165 “
Heavy Pennsylvania crude oil ..	11520 “	Rape oil	9500 “
Heavy Caucasian crude oil ..	11188 “	Lard	9380 “
Light Caucasian crude oil ..	12240 “	Tallow (beef)	9357 “

The temperature (Centigrade) reached by complete combustion of a fuel at a temperature of 0° and a pressure of 760 mm Hg. is called heat intensity, pyrometric heating effect or combustion temperature. This does not depend only on the amount of heat developed during the process of burning but also on the amount and the specific heat of the products of combustion. A high combustion temperature is favoured by complete combustion and the production of a residue of low heating value. These conditions can be best secured by warming the fuel and air before burning, by limiting the amount of air, and by the use of dry air and fuels with small ash and water contents.

The determination of the temperature of combustion is made by means of a pyrometer.

Fuels (Liquid) see "MAZUTE".

Fuller's earth. A hydrosilicate of magnesium and aluminium which possesses strong decolourizing properties. It is used for decolourizing animal, vegetable and mineral oils and fats. It occurs as granular masses of different sizes and also as a powder of varying degrees of fineness.

Fulminates. Salts of fulminic acid $C : NOH$, a substance which has been little investigated. Silver and mercury fulminates are the most important.

1. **MERCURY FULMINATE.** $Hg(C : N.O)_2 + \frac{1}{2} H_2O$. Is prepared by dissolving Hg in excess of HNO_3 and allowing alcohol to act on the solution. The fulminate separates in very small white needles which be purified by washing with water. To avoid explosions it is kept under water. It can be made to explode by rubbing, by a sudden blow or by heating to 190° . Mixed with nitre and sulphur it is used for filling percussion caps.

2. **SILVER FULMINATE.** $Ag_2(C : N.O)_2$. Prepared similarly to the above. Even greater care must be taken as it is extremely explosive. It is used for the preparation of crackers and detonating balls.

Fusel oil. By-product of alcoholic fermentation, especially in the preparation of potato spirit and in the rectification of alcohol. It is an oily liquid which floats on the surface of the residue left in the distilling apparatus. The chief constituents of potato fusel oil are amyl alcohol, various esters, furfural, &c. Further details will be found in the article on "AMYL ALCOHOL".

Furnaces. According to the method of heating a distinction is drawn between 1. furnaces in which the substances to be heated are in direct contact with the fuel, i.e. those which have no special heating arrangement; 2. furnaces in which the substances come in contact with the flames only and are heated by these and the hot furnace walls; and 3. furnaces in which the substances are contained in vessels heated externally.

To the first class belong hearth and shaft furnaces.

1 a. **HEARTH FURNACES** consist of low fire-places or hollows, either completely open or closed in by low walls on one or several sides. The combustion of the fuel which is in direct contact with the substances is effected either by natural draught or by an air blast.

1 b. **SHAFT FURNACES** are of masonry, and are tall in proportion to the width. The upper opening is used to introduce the fuel and the substances to be heated. The solid and liquid products are removed through openings at the base of the shaft. The fuel is burnt by air introduced at the bottom (either by suction or by blowing); the combustion gases escaping at the top pass, on their way, over the material to be heated. Shaft furnaces are used for roasting (Roasting furnaces), smelting (smelting furnaces), and for evaporation. Shaft furnaces more than 4.5 m in height are also called blast furnaces. Frequently shaft furnaces are much like those to be mentioned in class 2. In these cases they have a separate firing place and only the flames enter the shaft. Finally, shaft furnaces are also heated by producer gas or gas fuel. Cupola furnaces are also shaft furnaces; they are used for melting cast iron in casting works.

2. **Furnaces in which the substances to be heated come in contact only with the flames** are called reverberatory furnaces, because the heat is reflected from the hot furnace walls. Reverberatory furnaces can be classed as of the shaft type (discussed above), or as real reverberatory furnaces. They are long and wide in proportion to the height, with a horizontal or only slightly inclined bed, in which the substance to be heated is separated from the fuel by a wall (fire bridge), so that it is only touched by the flames. Gas fuel is also very frequently used in reverberatory furnaces.

3. There are also furnaces provided with vessels to contain the substances to be heated. The hearth is sometimes shaft-like, dome-shaped, or conical. The vessels are of various forms; they may be crucibles, retorts, pipes, boxes, &c., thus giving rise to distinctions between crucible furnaces, retort furnaces, pipe furnaces, &c.

Furnaces:

Willy Manger, Dresden, Germany.

Combustion furnaces with Benzene firing:

Gustav Barthel, Dresden-A. 19 (see front part advt.).

Crucible furnaces:

Gustav Barthel, Dresden-A. 19 (see front part advt.).

Muffle furnaces:

Gustav Barthel, Dresden-A. 19 (see front part advt.).

Furnaces, electric. The heating of substances in electric furnaces is either effected by the resistance (low voltage and high current strength) or by means of the electric arc (high voltage, low current strength). According to BORCHERS ("Entwicklung, Bau und Betrieb elektrischer Öfen") we have to distinguish between:

I. Heating by resistance.

1. The substance to be heated is itself included in the circuit as part of the resistance.

2. The substance to be heated is in contact with an electrically heated resistance.

II. Arc heating.

1. The substance to be heated forms one or both poles of an arc.

2. The substance to be heated is placed in a space heated by an arc.

Furnace gas testing apparatus:

Optical analysis according to Prof. Haber: Prosp. Carl Zeiss, Jena (Germany).

G

Gadose. A grease prepared from cod-liver oil and lanoline. It forms yellowish crystals M. P. 37.5°; iodine number 43.7; saponification number 152; acid number 0. Mixes with glycerine in all proportions and can be used as an ointment basis since it mixes well with most drugs.

Galalith. The trade name for a horn or celluloid-like substance. The method of preparation is protected by various patents. The most important of these are the Germ. Pats. 115681, 127942, 141309 and 147994.

Briefly, galalith is obtained by the action of formaldehyde on caseine. Separated milk is treated with alkali carbonates when a solution of caseine is obtained. This is clarified, the casein precipitated with acids, filtered, partly dried by pressure and then dried very slowly. The actual drying takes weeks or even months. The plates so obtained are saturated with formaldehyde and again dried. The finished product so obtained is a yellowish-white, very translucent substance of horn-like toughness. If a coloured, or marbled preparation is required the dyes are added to the caseine solution, or cork powder, soot, cellulose, earthy substances are thoroughly incorporated with the precipitated caseine, or lead acetate, &c. are used instead of acids for the precipitation.

According to HASSACK galalith has a S. G. 1.317—1.35; its hardness is 2.5 according to MOHR'S scale. It is a strong electric insulator, can be worked

cold, and, when warmed with water, can be kneaded and moulded. An advantage over celluloid possessed by this substance is that there is no smell of camphor and that it is not easily inflammable. On the other hand it cannot be obtained perfectly transparent nor in very thin leaves. The thinnest leaves obtainable are at least 2 mm in thickness.

Galalith is already fairly well known, and is certain to be used more widely in the future.

Galbanum. A gum obtained from *Ferula galbaniflua* of the Caspian area and from other plants. Occurs in greyish or brownish granules or pieces, or sometimes in the semi-liquid form. It has an aromatic, but rather unpleasant odour and a bitter taste. It is used in medicine as an irritant and also in the preparation of adhesives. Acid number (direct estimation) 5—70; ester number 50—180; saponification number (determined hot) 75—245; total saponification number 107—123; methyl value 3.7; ash 1—30% (more than 10 % is not allowed); loss at 100° C. 1—30 %. Only partially soluble in indifferent solvents. Water dissolves 20 % and alcohol up to 90 %.

Gallic acid, trioxybenzoic acid. $C_6H_2(OH)_3 \cdot CO_2 + H_2O$. This acid is frequently found together with tannins in various plants, especially in galls. It is extracted by water from various parts of the plant, the decanted extract is allowed to ferment and then the gallic acid which separates crystallized from boiling H_2O . The ferment decomposes the aqueous solution of tannic acid into gallic acid and CO_2 .

Recently gallic acid has been obtained by decomposing tannin with dilute H_2SO_4 or KOH . The Germ. Pat. 129164 makes use of the property possessed by certain fungi (e. g. *Aspergillus gallomyces* found on the gall nut) of converting tannin into gallic acid. These fungi are now, according to the method given in the above patent, prepared in the form of pure cultures for the fermentation of tannin extracts.

When pure it forms colourless, odourless crystals (needles) with bitter acid taste. They readily dissolve in hot water and in alcohol, less readily in cold water and only with difficulty in ether. At 200° gallic acid decomposes into CO_2 and pyrogallic acid (see PYROGALLOL). Besides being employed for the preparation of pyrogallic acid, gallic acid is also used in photography on account of its strong reducing properties.

Gallicine = gallic acid methylester. $C_6H_2(OH)_3CO_2CH_3$. A solution of one part gallic acid in 4 parts methyl alcohol is saturated with dry HCl -gas. After standing several days, the solution is evaporated to a syrup, mixed with $BaCO_3$ and the mixture extracted with methyl alcohol.

It forms crystals M. P. 202° C., soluble in hot H_2O , alcohol and ether. It is used by oculists as an antiseptic in conjunctivitis.

Gallium. GA. Atomic weight = 70.1. A very rare metal, obtained electrolytically by a complicated process. It is a bluish white, tough substance which can be cut with a knife S. G. (at 24.5°) 5.96. M. P. 30.15° C. It is not attacked by H_2O , even when boiling. It is easily soluble in KOH , NH_3 and HCl , slowly in HNO_3 . Neither the metal nor the compounds have any industrial value.

Gallogene = Ellagic acid. $C_{14}H_6O_8$. Yellow, odourless powder of agreeable taste, only soluble in alkalis. Consequently, in the human body it does not dissolve before reaching the intestine, where it becomes active. It is recommended as an astringent in cases of tuberculosis and inflammation of the bowels. Dose 0.3—0.5 g; or 2—2.5 g per day.

Gallon see APPENDIX.

Gallo-tannic acid see TANNIN.

Galls. Excrescences on leaf buds, leaves, and fruit caused by deposition of the eggs of the gall wasp. Galls contain an extremely large amount of tannic acid (from 60 to 70 % or more). They are used in tanning, dyeing, in the manufacture of inks, and of pure tannic acid, and medicinally as an astringent.

Commercially a distinction is made between: 1. Turkey (Asiatic) galls (those from Aleppo being the best known), 2. the much smaller European galls which rarely contain more than 30 % of tannin, acid and 3. the China galls which contain up to 77 % tannic acid. The latter are not caused by wasps but by a species of plant louse.

Galvanoplastic.

Galvanoplastic:

Cannings, Great Hampton St., Birmingham.

Galvanizing:

Cannings, Great Hampton St., Birmingham.

Gamboge. The gum of *Garcinia Morella* Desr. found in East India and Ceylon. The juice is obtained by cutting and is collected in bamboo tubes. Impure kinds are obtained by boiling the leaves and unripe fruit.

Reddish-yellow substance covered with a greenish dust; conchoidal fracture. Deep-yellow emulsion with water. It is used as a drug, though its chief use is as a colour (see VEGETABLE DYE STUFFS).

Gas analysis.

Absorbents for various gases ¹⁾.

Name of gas	Absorbent	Name of gas	Absorbent
Carbon dioxide.	Solid KOH or solution of 1 KOH in 2 H ₂ O.	Nitrous oxide.	Concentrated H ₂ SO ₄ (S. G. 1.702) or aqueous solutions of the alkalies.
Carbon monoxide.	1. Ammoniacal or hydrochloric acid solution of Cu ₂ Cl ₂ (not to be used in presence of acetylene and ethylene). 2. Blood + NH ₄ . HS (spectroscopic method). Fuming H ₂ SO ₄ .	Oxygen.	1. Strong alkaline solution of pyrogallol (5 g pyrogallol in 15 g H ₂ O, mixed with 120 g KOH in 80 g H ₂ O). 2. Solution of chromous chloride. 3. Phosphorus.
Ethylene.	Palladium (palladium sponge).		4. Cu at a red heat, Cu at ordinary temperature in presence of solutions of NH ₃ or ammonium carbonate.
Hydrogen.	Aqueous solution of ferrous salts (1 FeSO ₄ cryst. in 2 H ₂ O).		
Nitric oxide.	Mg-wire (at a high temperature, near the M. P. of glass).	Ozone.	Oil of cinnamon or turpentine.

Gas lamps see LAMPS.

Gas lighters, automatic. These are devices intended to render unnecessary the use of matches for igniting coal or other gases. The principle was dis-

¹⁾ This and the following table are taken from v. BUCHKA'S "Physikalisch-chemische Tabellen der anorganischen Chemie". Stuttgart 1895.

Absorbents for quantitative determinations.

Name of gas	Absorbent and quantitative determination	Name of gas	Absorbent and quantitative determination.
Acetylene.	Ammoniacal solution of CuCl_2 . The precipitate of copper acetylide (C_2Cu_2) is converted into CuO which is weighed.	Hydrochloric acid.	1. Known volume of normal alkali; excess back-titrated with normal acid. 2. Aqueous alkali solutions (free from chlorine). The HCl absorbed is precipitated in the acidified solution as AgCl .
Ammonia.	1. Known volume of normal HCl (or H_2SO_4); the excess of acid is back-titrated with normal alkali. 2. Sodium hypobromite: The volume of N set free is measured.	Hydrocyanic acid.	KOH -solution: AgCN is precipitated by addition of AgNO_3 , converted into Ag by heating and weighed.
Antimonyretted hydrogen.	AgNO_3 -solution: The SbAg_3 formed is converted into antimony sulphide and the latter weighed.	Nitrogen oxides.	KMnO_4 -solution acidified with H_2SO_4 . The NO is converted into HNO_3 , and the excess of KMnO_4 back-titrated with $\text{C}_2\text{H}_5\text{O}_4$.
Arseniumretted hydrogen.	AgNO_3 -solution: The As_2O_3 formed is weighed as magnesium pyroarsenate.	a) nitric oxide, b) nitrogen trioxide, c) nitrogen peroxide.	
Carbon dioxide.	Barium hydroxide solution of known concentration; the excess of Ba(OH)_2 is determined volumetrically by normal oxalic acid.	Ozone.	Aqueous KI -solution: The I is titrated with $\text{Na}_2\text{S}_2\text{O}_3$ solution.
Chlorine.	Aqueous KI -solution: The I set free is determined volumetrically with $\text{Na}_2\text{S}_2\text{O}_3$ solution.	Phosphine.	Bromine water: The H_3PO_2 formed is weighed as $\text{Mg}_3\text{P}_2\text{O}_7$.
Cyanogen.	KOH -solution: The KCN and KCNO are precipitated with AgNO_3 , and the precipitate converted into Ag by heating.	Sulphuretted hydrogen.	1. Bromine water: The H_2SO_4 formed is weighed as BaSO_4 . 2. Copper sulphate-pumice stone in tubes, weighed before and after.
		Sulphuric anhydride.	Bromine water: The H_2SO_4 formed is weighed as BaSO_4 .

covered by ROSENFELD in 1888. The gas passes over a "lighter" covered with fine platinum wire. The lighter is raised to a red heat, the platinum becomes white-hot and the gas is ignited. The construction varies in different types, more particularly as regards the position of the lighter. For incandescent lighting it may be fixed to the mantle itself, or attached to the chimney above, or below to the burner itself.

The automatic lighters introduced and patented by KILLING in 1898 have not been successful.

In the case of those fixed above the light their activity is not of any great duration since they are constantly exposed to the influence of heat. The best are those fixed below the burner e.g. "Fiat-Lux" and "Stabil". The former is carefully constructed; the latter is provided with a three-way tap, is of simple but strong construction and lights easily.

Gas, lighting by see BURNERS, LAMPS, COAL GAS and GASLIGHT, INCANDESCENT.

Gaslighting, incandescent. Various metals of the cerium group are used in the preparation of mantles. The principal mixture used consists of 99 % thorium nitrate and 1 % cerium nitrate. These substances are usually obtained from monazite and to a smaller extent from thorite, gadolinite, &c. The "stockings" made of cotton, or better of ramie are impregnated with a solution

of the salts, and then heated so that a skeleton of the oxides remains which retains the structure of the original stocking. To increase the durability ammonium nitrate or an alkali salt is also added.

Mantles of high illuminating power for use with a mixture of oxygen and coal gas are prepared (Germ. Pat. 157811) by the following method. A solution of calcium nitrate containing cerium is used either alone or mixed with zirconium nitrate. The stocking is soaked in this, dried, burnt, and the skeleton dipped into a solution of thorium nitrate, again dried and once more ignited.

Instead of employing a cotton basis, it has been attempted to prepare filaments in a gelatinous form. One method (Germ. Pat. 135534) consists in treating solutions of the rare earths with a solution of cellulose in the cupro-ammonia solution and proceeding as in the manufacture of artificial silk (q. v.). The mixture is converted into filaments which are coagulated, washed and dried. The coagulation is accomplished by treatment with neutral or alkaline solutions, usually with a solution of KCN. According to Germ. Pat. 141244 fibres of artificial silk (i. e. cellulose) can be impregnated with the rare earths. They must be passed after drying through an alkaline bath in order to convert the nitrates into hydroxides. Filaments of nitrocellulose can be impregnated with the rare earths (Germ. Pat. 161262) without previous denitration provided they are properly soaked in suitable solutions (formic acid, acetic acid or nitric acid of certain concentrations). Germ. Pat. 178832 describes a method of preparing mantles from artificial silk by a process of igniting, shaping and hardening the woven material.

A special method of drying the impregnated mantles is protected by Germ. Pat. 154808. The mantles are dried on glass moulds, not by allowing the hot air to play directly upon them but by the moulds being heated inside by steam, hot air or hot liquids.

Mantles which light automatically are prepared (Germ. Pat. 158974) by soaking in a solution with subsequent reduction, so that an igniting mixture is formed. (NH_4Cl is added to the solution of rhodium chloride.)

The mantles are heated by burners which are identical in principle with the ordinary Bunsen burner.

In order to prevent the breakage of ignited mantles, the latter are treated with a stiffening material which usually consists of a solution of collodion in alcohol and ether. After the evaporation of the solvent the mantle is covered with a film of collodion, is no longer fragile and can be readily transported. The collodion is of course destroyed when the mantle is used for the first time.

According to Germ. Pat. 153346, the ether of this dipping mixture can be replaced by a mixture of acetic acid and acetone. The inflammability of the solution is thereby diminished. A similar result is obtained (Germ. Pat. 153758) by dissolving the collodion in concentrated acetic acid.

In order to render the mantles more durable after burning and shaping (by the pressure burner) they are treated first with a solution of zirconium nitrate and then with one of collodion, without any further ignition (Germ. Pat. 180047). The mantles may also be dipped into a mixture of collodion and zirconium nitrate solutions and then dried. The collodion solution is made of 650 g collodion, 270 g ether, 50 g castor oil, and 20 g camphor. The mantles prepared in this way should not suffer any damage when subjected to pressure.

Cf. CERIUM and THORIUM.

Gas liquor. The aqueous condensation product obtained in the purification of coal gas (q. v.). It is a valuable substance for the preparation of ammonia and contains from 3 to 30 % (or even more) of ammonia mainly in the state of carbonate. The English Pat. 9396 (1903) which is concerned with the treatment of the gas liquor with metallic solutions (especially FeSO_4 solution) in order to remove H_2S and cyanides, calls for no comment.

Gasliqnor-Distilling-Apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Gas oil. The name applied to all mineral oils intended for the preparation of gas (cf. OIL GAS). Such oils are:— The LIGHT OILS of brown-coal-tar (solar oil and gas oil), shale oil and the fractions between kerosene and lubricating oils obtained in the distillation of crude petroleum (the so-called SOLAR OIL). The smaller the range of boiling point of the oil, the greater is its value. According to KREY the extreme difference in B. P. between highest and lowest should be 100° , i. e. the oil should boil between 200° and 300° or between 250° and 350° . The amount of unsaturated hydrocarbons and resinous substances soluble in H_2SO_4 (S. G. 1.83) should not exceed 25 %, otherwise too much tar and coke are formed when the oil is converted into gas. Both EISENLOHR and KREY maintain that the value of the oil (or in other words the illuminating power of the gas obtained from it) depends upon the amount of paraffins present. Creosote should not be present to the extent of more than 2–3 %. If this amount is exceeded the value of the gas is lowered.

Gasoline cf. PETROLEUM. Gasoline is a colourless liquid with a penetrating ethereal smell. S. G. 0.64 to 0.667. B. P. $70-80^{\circ}$. It is used principally for the preparation of gas by blowing air through it. Gasoline is a convenient source of light in places not conveniently supplied from gas-works.

Gas pumps. Made of earthen ware. They are combinations of the usual plunger-pump with cylinders filled with some indifferent liquid which transmits the motion of the plunger. The valves and all parts exposed to the action of the gas are made of acid-resisting material, so that the pumps may be used for chlorine, &c.

Gas tar see "COAL-TAR".

Gaultheria, Oil of. (WINTERGREEN OIL.) An aromatic essential oil obtained from *Gaultheria procumbens*. The artificial product obtained from the methyl ester of salicylic acid is generally used in place of the natural substance (see SALICYLIC ACID, ESTERS OF). It is used in the preparation of fruit essences, for scenting soap, &c.

Gay-Lussac Tower see "SULPHURIC ACID".

Gelatine. Gelatine is a very pure glue; the principles of its preparation will be found under "GLUES". Gelatine is obtained either from calves heads or the cartilage and skins of young animals. The raw material must show no signs of decomposition, and in the process of manufacture all decompositions must be avoided. An essential condition for obtaining a good product is the careful cleaning of the original material and the clarifying of the glue solution. For bleaching, sulphurous acid is used; the latter also assists in preventing decomposition during the manufacture.

Special purity is required for photographic gelatine, since the smallest amount of putrefaction causes the formation of reducing substances which destroy the silver salts present in the film. Photographic gelatine is chiefly obtained from skin tissues as these possess in a high degree the property of coagulation. The head and leg portions of calves, which are useless for leather purposes, are chiefly employed for this purpose.

A special method deals with the preparation of gelatine from brown bone glue:— The latter is ground, well soaked, melted with H_2O and finally treated

with oxalic acid to destroy the brown colour. It is not known, however, if this method has proved satisfactory.

Gelatine is generally sold in the form of very thin leaves, a form originally chosen in order to facilitate rapid drying. An addition of sugar and alcohol renders the leaves more flexible; frequently they are dyed with coal-tar colours. Recently, however, gelatine has been produced in thicker plates, and also as threads and as powder.

Apart from its use for culinary purposes and in the preparation of photographic films, &c. gelatine has recently found numerous other applications. The gelatine capsules, much used in medicine, are made of gelatine and glycerin gelatine. Gelatine is made in a form in which it is quite insoluble in H_2O and not readily attacked, by treatment with formaldehyde. In this form it is used for making photographic films, vessels, ornaments, and spangles for dresses, &c.

TEST. The best gelatine should be in thin, transparent, nearly colourless leaves of glass-like appearance. It should be absolutely tasteless and odourless. Gelatine swells in cold and dissolves readily in hot H_2O , yielding a clear or opalescent solution. On cooling, a solution of 1 g gelatine to 100 ccm H_2O should become a jelly. Gelatine is insoluble in alcohol and ether; a diluted solution is precipitated in a flocculent state by tannic acid solution. Possible impurities are inorganic substances, free acids and H_2SO_4 . On burning, 1 g gelatine should not leave more than 0.02 g ash. To test the absence of free acids and H_2SO_4 1 g gelatine is dissolved in 100 ccm hot H_2O ; a part of this hot solution is tested with a $BaCl_2$ -solution, when only a faint opalescence should result. For other acids a piece of blue litmus paper is placed in the remainder of the hot 1 % solution, when the paper should not turn red.

Gelatine manufacturing Plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Gelatine carbonite see "SAFETY EXPLOSIVES".

Gelatine dynamite see "DYNAMITE".

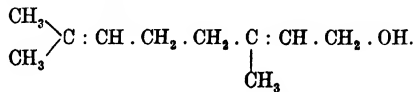
Generator gas see „GAS“.

Generator gas-Plant:

Willy Manger, Dresden, Germany.

Geranial see "CITRAL".

Geraniol. This substance, much used as a perfume, is a terpene alcohol $C_{10}H_{17}$. OH of the following constitution:—



It is present to the extent of 65—80 % in oil of rose and also in considerable quantities in geranium and citronella oils. With $CaCl_2$ it forms a crystalline derivative which can be prepared by rubbing oils rich in geraniol with the salt. By washing the recrystallized compound with ether and decomposing with water geraniol is obtained.

It is sold commercially not only in the pure state, but also after distillation over the flowers of roses, hyacinths and mignonette and is then sold as rose-geranium oil, hyacinth-geranium oil or mignonette-geranium oil respectively. The preparation of α -substituted geraniols by the action of magnesium-alkyl-

halogen compounds on citral and the decomposition of the magnesium-halogen compound with water is protected by Germ. Pat. 153120 and 154656. These alkyl derivatives have a purer, more delicate and yet more powerful odour than geraniol itself.

Geranium, Oil of. (*Oleum Andropogonis*.) An essential oil obtained from various kinds of *Pelargonium* and *Andropogon* growing in southern Europe.

Colourless, yellowish, or slightly brownish oil with a strong rose-like smell and an acid reaction. S. G. (at 15°) 0.886 to 0.906; M. P. — 16°. B. P. 210° to 230° [α]_D — 6° to — 16°.

The saponification number varies from 45 to 100. The chief constituent is geraniol. It is used in perfumery. The principal kinds are the French, African, Spanish and Réunion oils. In addition to these there are Indian (Ginger-grass oil) and East Indian (Palma-rose oil) varieties.

Geranyl acetate. $C_{10}H_{17} \cdot C_2H_3O_2$. Prepared by heating geraniol with acetic anhydride and sodium acetate. It is a liquid S. G. (at 15°) 0.9174; B. P. (14.5 mm) 129—130.5°; at the ordinary pressure it boils with decomposition at 242—245°. It has a pleasant refreshing bergamot-like smell. In combination with geraniol it has the smell of the wild rose.

Germanium. Ge. At. W. 72.5. A very rare element occurring in ARGYRODITE, CONFIELDITE, EUXENITE and SAMARSKITE. In the periodic classification it stands between silicon and tin. Germanium and its compounds are of no technical importance.

Gilding. The earlier method is now but rarely used; it consists in placing the articles (made of copper or copper alloys) in a solution of mercurous nitrate and then applying a gold amalgam with a soft brush. The articles are then rinsed, dried in sawdust and the mercury evaporated by slow and uniform heating over a charcoal fire. Scraping with soft brass brushes and subsequent polishing with blood-stone finishes the operation. The gold amalgam necessary for fire gilding is made by dissolving gold in Aqua regia, precipitating the metal with ferrous sulphate, washing, drying, and stirring with mercury heated to about 150°. After cooling the Hg is pressed out, and the amalgam is left as a soft mass.

Gilding is carried out electrolytically either in a hot or in a cold bath. The former method is usually employed where small articles are to be gilded while for large objects a cold bath is used. See ELECTROPLATING.

SOLUTION FOR COLD GOLD PLATING¹⁾: 60 g gold chloride (= 30 g Au) are dissolved in about 200 g distilled H_2O , about 20 g ammonia (S. G. 0.969) are added and then a solution of 130 g chemically pure KCN²⁾ in about 900 g distilled H_2O . The colourless solution is filtered and then diluted to 10 l. by adding distilled water. It is advisable to add 20 g potassium formate.

SOLUTION FOR WARM GOLD PLATING²⁾: Three solutions are prepared, a) 10 g gold chloride in 1 l distilled H_2O , b) 600 g sodium phosphate in 8 l. distilled H_2O , and c) 20 g potassium cyanide + 100 g pure dried sodium bisulphite in 1 l. distilled H_2O . The solution a) and b) are mixed and then c) added. When steel and not copper, copper alloys or silver are to be plated without previous copper plating, solution c) should be 10 g KCN + 100 g pure sodium sulphite in 1 l. H_2O . The bath is used at a temperature of about 70° C.

Gold leaf or platinum foil is used as anode. The latter is recommended for warm solution. The less the platinum anode dips into the solution the lighter

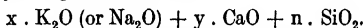
¹⁾ Steinach und Buchner „Die galvanischen Metallniederschläge“.

²⁾ Purest KCN (99%) must be used.

is the colour of the deposit. As the platinum anode does not dissolve in the bath the gold precipitated must be replaced at intervals by adding gold chloride and a little KCN.

The most suitable current density for gold plating is 0.2 to 0.25 ampères per sq. cm.

Glass. Glasses may be divided into lime glasses and lead glasses, and the former again into lime-potash and lime-soda glasses. The composition is represented by the general formula



In the lead glasses the CaO is replaced by PbO.

Of recent years the production of different kinds of glass has increased to an extraordinary extent, a result largely due to the labours of SCHOTT & GEN. of Jena. The Jena glasses prepared by this firm used for fine lenses for optical work, for apparatus which resists the action of chemicals, &c., &c. are widely known. In addition to the above mentioned varieties, there are barium and borate glasses. In the former the PbO of lead glass is replaced by BaO, while in the latter kind boric acid takes the place of the SiO_2 . Between the different kinds are many glasses intermediate in composition.

The raw materials used in glass manufacture are silica, the fluxes and the decolourizing or colouring substances.

1. SILICA. Used in the form of sand, kieselguhr or quartz. Earthy admixtures (clay) yield a more easily fusible glass. (See Quartz glass).

2. FLUXES. The principal are:— Potash, soda, lime, baryta, strontia, lead oxide, boric acid, zinc oxide ¹⁾ and certain natural silicates. Potash is used generally as carbonate or sulphate, soda as sulphate (sometimes as NaOH). Lime for the preparation of white glass must be free from iron. It is used either as carbonate (marble, chalk, &c.) or as quick-lime.

For the manufacture of milk glass, calcium phosphate is employed. The barium glasses are used for optical purposes since they are much harder than the lead glasses and have almost as high refractive indices. The lead oxide chiefly used is minium as with it little reduction to metallic lead occurs. Calcium plumbate is sometimes employed in the manufacture of lead-lime glass. Boric acid alone or mixed with borax is used for making optical glasses and enamels.

Where they can be obtained cheaply and in the immediate neighbourhood of the works various natural silicates are used, e.g. basalts, trachytes, granites, feldspars, micas, obsidians, lavas and pumice. Finally glass residues (shearings, clippings, &c.) are always added to the extent of at least $\frac{1}{3}$ the total amount of flux.

3. DECOLOURIZING and COLOURING MATERIALS. Arsenious acid is much used as a decolourizer. It acts as an oxidizing agent towards the carbon, sodium sulphide and ferrous compounds present, and since it causes the fused glass to "boil", it helps to mix intimately the constituents. KNO_3 acts both mechanically and chemically as a purifying agent. More recently a method has been adopted of passing a current of oxygen through the fused glass: it acts as a strong decolourizing agent. Nickel oxide and manganese dioxide are used in decolourizing optical glass. The latter imparts to the glass an amethyst colour which neutralizes the green due to the presence of iron. Since, however, the resulting glass is of a pale violet tint, nickel oxide is used in place of the MnO_2 : a perfectly colourless glass is thus obtained. For colouring materials see GLASS, COLOURING.

¹⁾ The oxides of Bismuth and Thallium are used for making optical glasses of high lustre for lenses and optical instruments.

The raw material is broken up, mixed in the proportions desired and fused with broken glass (cullet). The melting is carried out in pots or crucibles. The pots are round, open or covered, are made of fire proof clay and are smaller at the bottom. They hold 60 to 1000 kg or more and are manufactured in the glass works. For the manufacture of mirrors, crucibles square in section are used. These have a broad rim all round to facilitate lifting with the tongs.

The glass furnaces are of the vertical reverberatory type containing 6—10 crucibles with extra space for softening any pieces of glass which are in process of being worked. An essential condition for the production of a good batch is the absence of carbon and ashes in the work shop. Formerly only wood was employed but now other fuels, such as coal lignite and peat are used.

The most important improvement in glass manufacture is the introduction of gas heating by SIEMENS, which renders it possible to have a clear fire with inferior fuel. In most glass works SIEMENS' regenerator furnace is now in use. It consists of a generator for the heating gas, regenerators in which the gases and the air (introduced through pipes) are heated and the melting furnace itself. The more modern SIEMENS' crucible furnaces, which are likewise heated with producer gas, need no extra crucibles, the deep bottom being so shaped that the batch can be melted in the furnace itself. Compare PRODUCER GAS. The Germ. Pat. 124702 gives a process for the manufacture of glass by electrical methods. The glass mixture is brought into contact with the electrodes in the chamber and there fused by the voltaic arc. The molten mass then passes into the refining chamber, where it is further treated. The points which characterize this process are these:— The mass is melted by the heat of the arc, and the refining is carried out by the heat of resistance. The glass is melted in a narrow chamber, where impurities of all kinds such as gases and so on are excluded. The current used is weak but continuous, so that the process of melting and refining is carried on uninterruptedly. The process of refining can be carried out much more satisfactorily and more quickly by this method: the heat can, of course, be regulated. Improvements on this method are protected by the Germ. Pat. 128250, 131291, and 134935. (See also Germ. Pat. 167023.) The use of electricity for the manufacture of glass has as yet, however, not become prevalent.

The different kinds of glass vary greatly in quality, the composition depending upon the materials and proportions used. It has been determined that a mixture in which the silicic acid contents are sufficient to form a trisilicate is the most suitable for the manufacture of chemical apparatus, the proportion of lime to alkali being 1 : 1.3 to 1 : 1.5. A glass in which the proportions are $\text{SiO}_2 : \text{CaO} : \text{K}_2\text{O} \text{ or } \text{Na}_2\text{O} = 7.2 : 1 : 1.34$ is especially suitable for resisting the action of boiling water and dilute acids. It should be further noted that potash glass is more soluble than soda glass. An increase in the amount of silica increases the resistance of glass to solvents, but on the other hand it renders it more brittle and less fusible. The formation of glass in the crucible proceeds gradually as the temperature rises.

The liquid mass "boils", the gases escape and the compounds, such as sulphate, which do not pass into the glass substance collect on the surface in "galls". These are afterwards burnt off with hot ashes, or if very numerous they are scooped away. The heat is then increased to make the glass regular, more liquid and clearer. This latter operation is termed refining or clearing. In the later stages of glass manufacture there are two main varieties, plate glass and blown glass. The molten glass is taken out by dipping the pipe into it and then simply "blown", or it is blown by the aid of different irons, tongs, plates, &c. into the desired form and shape. The glass which is directly blown into moulds is termed pressed glass.

Plate or rolled glass is blown into larger tubes the ends of which are afterwards broken off. The tube is then opened and slowly heated in a flattening

furnace till the curve flattens out and a rough plate is formed which is then rolled smooth.

The thick glass for mirrors, shop windows, &c. is now no longer blown, the material being poured straight from the crucible on to plates, and after it has solidified it is cut and polished.

P. SIEVERT has introduced a particularly interesting and important method for treating glass. This method is protected by a large number of patents of which the most important are the Germ. Pat. 111393, 154888, 156584, 156585 and 157847. The still molten glass is poured on to an iron mould shaped like the object to be produced, the mould is then turned to an angle of 180° when the glass mass which sticks to the edges of the mould swings out by its own weight into a kind of sack. The mould has vents through which compressed air is introduced and this blows the "sack" still larger, the shape being determined by that of the mould. In this way baths, accumulator cases and other vessels are blown. For smaller articles it is not even necessary to blow in air, the mould is slightly moistened before the glass is poured into it, steam is formed and the glass assumes the shape of the mould. See also HARDENED GLASS, STRASS, and WATER GLASS, and GLASS, COLOURING.

Glass, colouring. Metallic oxides or metallic salts which are converted in the glass into coloured silicates are as a rule used for producing the desired tints. The most frequently employed are compounds of iron, manganese, copper, cobalt, silver chromium and gold.

1. **IRON.** Ferrous oxide is used for producing greens; with oxides of iron yellow, orange, red, brown, and violet tints can be obtained, but they all more or less tend to pass back into the protoxide. The green colour is best brought out by adding the Fe in the form of ferrous sand or clay.

2. **MANGANESE.** This substance is added to the glass in the form of MnO_2 . It produces a violet-red. The colour is easily destroyed by the action of reducing agents. By adding Fe_2O_3 or CuO to the glass after the manganese a grey glass can be obtained. A large amount of MnO_2 gives a black glass.

3. **COPPER.** CuO colours glass blue green, Cu_2O blood red.

4. **COBALT.** Cobalt, either as pure oxide or in the form of azure blue, Thénards blue, &c. gives the glass a blue colour.

5. **SILVER.** Compounds of silver make glass (more especially lead glass) yellow.

6. **CHROMIUM.** This substance is used for producing an intense yellow-green glass. It is mostly used in the form of Guignet's green, which is prepared by heating potassium bichromate with borax.

7. **GOLD.** This metal is employed for the manufacture of real ruby glass. Formerly it was used in the form of purple of Cassius, though now solutions of gold chloride are preferred. Compare also GOLD COLOURS. The rose-red to purple of the colour is first perceptible when the glass is worked. The Germ. Pat. 138281 gives a method for making massive gold ruby glass from baryta glass in which so much dissolved or finely powdered gold is mixed as corresponds to a proportion of 0.25 — 1.7 parts to 10000 parts of sand. The mixture is then melted in the glass furnace. Na is used as an alkali and Ba in the form of $Ba(NO_3)_2$ as a divalent metal. To ensure success a reducing agent is added during the process of melting.

8. **SELENIUM.** This substance is now often used for colouring glass red, but it is still principally employed for making green glass colourless.

There are many other metallic compounds in use for colouring glass, for instance uranium oxide gives a bright green fluorescent colour (the so-called uranium and Anna yellow glasses). Sulphides of antimony give a golden tint

and together with copper sulphide a sepia colour. With a molybdenum-sulphide a deep red-brown shade is obtained.

Other glass colours do not actually colour the glass but convert this substance into a coloured mass. In this way the peculiar colours are produced which are now often seen. Charcoal and many other organic compounds which carbonise in the glass transform the sulphates into sulphides with the above result.

Metallic compounds which are either insoluble or only partially soluble in glass are used for producing semi-transparent glass. Milk glass, bone glass, opal glass, spar glass and other kinds are made in this way. Germ. Pat. 165986 provides for the addition of sand, feldspars poor in lime and sodium fluosilicate to the mixture in order to give milk glass. It is difficult to understand what there is in this method that can be patented.

Coloured glass is made by dissolving some of the above named or other metallic compounds in the glass flux. A distinction is drawn between coloured glass proper and flashed or cased glass. The latter variety is made by covering a thick layer of colourless glass with a thin coating of coloured. In this way several colours can be laid on, one over the other. Multicoloured designs can be produced on glass objects by cutting, grinding, and etching the outer layers.

Iridescent glasses are produced by exposing the ready made glass in a hot furnace to the action of metallic chlorides. Metal lustres are also prepared by firing metallic salts or oxides, e. g. B, Ag, and Cu after these have been painted on to the glass. RINDSKOPF in the Chem. Ztg. 1902, Repert. 243, gives as the necessary substances for producing the above effect, salts of tin, strontium nitrate or barium nitrate. One of these substances is volatilized by electricity in a suitable vessel and then conducted into the glass blow pipe, while still hot, through an opening in the stem which can be closed at will. After the glass has been subjected to the chemical for a certain time, the article is placed in a cooler.

According to Germ. Pat. 145629, glasses with powerful metallic reflection can be produced by exposure of the glass, which is painted in the ordinary way with metallic salts or oxides after the first reduction in the furnace, to an oxidizing atmosphere and then again to repeated processes of reduction and oxidation. The number of times the process is repeated will determine the degree of metallic lustre. The number of operations varies from 3 to 6.

Glass cements see "ADHESIVES".

Glass stone. Hollow building materials made from glass are applied (Germ. Pat. 133927) in factories, warehouses, &c. as windows or transparent walls. Single "stones" may be replaced without disturbing the rest. This is possible owing to the presence of projections on the lower surface which fit into corresponding depressions in the bed. These projections can be easily cut out.

Glass substitutes. One such substitute can be prepared (Germ. Pat. 178644) from viscose (q. v.) by spreading it in thin layers on textiles or goods woven from metallic substances, and then drying. Owing to the large amount of shrinkage that takes place the substance becomes almost transparent and can be protected by a coating of a non-inflammable varnish.

In order to carry out the process the object is dipped into a solution of viscose, the latter coagulated by the usual agents, and the mass dried. The resulting substance is flexible and nearly transparent.

Glass furnaces:

Willy Manger, Dreden, Germany.

Glover tower see "SULPHURIC ACID".

Glucose see "SWEETENING AGENTS, ARTIFICIAL".

Glucose (GRAPE SUGAR, DEXTROSE). $C_6H_{12}O_6$. The preparation of starch sugar depends upon the fact that starch (potato starch) on being boiled with H_2SO_4 first passes into soluble starch, then into dextrine and maltose and finally into dextrose. If the boiling is not continued long enough so that large quantities of dextrose and maltose are still present, the substance will not solidify but remains as a syrup; while if the process be continued longer the result will be solid glucose. The degree of concentration of the liquid starch and the solution of H_2SO_4 is of great importance; and in practice 1.5–2.5 parts of 1–2 % H_2SO_4 are usually added to 1.5 parts of crude starch or to 1 part of dry starch. The dilute acid is brought to boiling in wooden barrels with steam and the liquid starch is poured in from a stirring tub above. The water which evaporates must be continually replenished. When a sample no longer becomes blue on the addition of iodine, the fluid is boiled for half an hour longer and then run into special tubes where it is neutralized with $CaCO_3$ free from Mg. The precipitated matter is separated by being passed through filter presses, after which the solution of sugar is evaporated in open vessels to a specific gravity of 1.15 to 1.25. The gypsum is then allowed to crystallize out and the solution is decolorized by filtering over bone charcoal. When filtered the syrup is boiled *in vacuo* under a pressure of 0.2–0.3 atm. to a S. G. of 1.37–1.44. The thick syrup is then allowed to flow into large iron cooling pans to crystallize. The process of solidification can be hastened by adding a little dextrose, and it is necessary to stir continually so that the substance may become a smooth even mass. The sugar is finally poured into small vessels to solidify and comes on the market as box sugar. Various methods have been brought forward for refining this sugar. One of these is to press the sugar out of the fluid before solidifying by means of hydraulic presses or centrifugal apparatus. Another method is to treat the crude sugar with boiling methyl alcohol and allow it to crystallize at 30–40° C. Another way is to reduce the syrup to 46Bé. at 90° C and then allow it to crystallize slowly at 35–50°. The other methods must be passed over here. Starch syrup is produced from starch by means of acids in the same way as given above, only sufficient dextrine-like products must be present and the gypsum must be completely removed, to prevent crystallization of the sugar and to keep the syrup clear. 2–3 % H_2SO_4 and 300 % H_2O are used for this purpose and the mixture must be boiled just until the solution no longer gives a blue colour with iodine.

On account of the disadvantages of using sulphuric acid, attempts have been made to employ other acids, such as hydrochloric acid, oxalic acid and of late also hydrofluoric acid, but without much success. Starch sugar can, however also be obtained by converting the starch into sugar by means of malt instead of H_2SO_4 . Compare the article on "ALCOHOL". The starch is warmed with 350–400 % of H_2O and 1–3 % of malt till it becomes pasty, taking care not to exceed 70° C; it is then cooled to 55° C, when 4–7 % of green malt is added, keeping the temperature down to 55° by constant stirring. The sugar solution must be concentrated without delay to prevent fermentation, and is then brought on the market as EXTRACT OF MALT or SUGAR OF MALT.

According to Germ. Pat. 141589 grape sugar, $C_6H_{12}O_6 + H_2O$, is obtained from hard crystalline starch sugar by exposing the latter to a gradually increasing pressure. The lower the temperature the greater must be the pressure. The expressed liquid is said to carry away the impurities.

Glra. The cartilaginous substance of bones, sinews, skin, &c. is the part of the animal organism used for the preparation of glue; it is prepared from

these substances by prolonged boiling with H_2O , a process which gradually hydrates the glue-forming tissue and finally dissolves it. On cooling, these solutions form a very sticky elastic jelly which when dry has the appearance of a hard, horny, translucent mass. Glue does not dissolve in cold, but readily in hot water.

The working materials in the manufacture of glue are skins and leather, also bones, fish scales, isinglass, &c.

I. LEATHER GLUE (SKIN GLUE).

The best glues manufactured are those made from skins or leather. The skins of all kinds of animal are used, and also residues from tan-yards, slaughter-houses, &c. The raw material should be as fresh as possible. It is freed from traces of blood and flesh first by washing and then by treatment with milk of lime according to circumstances. It remains in the latter three weeks or less, when the material has to be freed from the last traces of lime, as otherwise the product would be inferior. This is done by careful washing and by treatment with dilute solutions of sulphurous acid or other acid solutions (e.g. spent tan liquor). Frequently a treatment with SO_2 is used in lieu of liming; if this method is followed the material is afterwards bleached with bleaching powder. The raw product thus obtained is once more carefully rinsed and then boiled with not too large an excess of H_2O . This "melting" is rarely performed over an open fire, but is effected either by direct or by indirect steam heat, the pressure not being allowed to exceed 1.5 atm. Very excellent glue is produced by means of steam alone, without the use of water. As the product is better the lower the temperature used during the preparation, vacuum apparatus has recently been employed. The spent raw material is used as dung, and the glue solution (containing 10—20 % glue) is further treated; it is purified by standing and filtering, and, if necessary, decolourized by animal charcoal. Other clarifying agents such as alum lessen the adhesive properties, which is the reason why dark, opaque glues are frequently preferred to the white, transparent varieties. The prepared glue solution is put into warm vats or at once cast in moulds. When vats are used the block of glue has to be cut into slices after cooling. The gelatinous slices obtained by either method are cut into smaller pieces and dried at a moderate temperature in airy drying rooms.

The Engl. Pat. 22738 (1902) is of importance under certain conditions. Tanned leather or leather wastes are "untanned" so that they may be used for the preparation of glue and gelatine according to the usual methods. In the case of chrome leather it is "untanned" by dipping into dilute H_2SO_4 after which it is rinsed with H_2O and neutralized with lime. In the case of leather tanned in the ordinary way a solution of alkali is used first and lime added afterwards. In either case the last traces of lime are removed by HCl and the latter acid again by alkali; the alkali chloride is finally removed by rinsing.

According to Amer. Pat. 748866 glue may be produced from skins by a treatment with aqueous sulphurous acid containing calcium phosphate and calcium sulphite. After this follows the usual solution in H_2O , neutralisation with lime and the final clarification.

Leather-glue-plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

II. BONE GLUE.

The manufacture of glue from bones is carried out in two different ways, and is generally connected with the manufacture of bone meal or of phosphorus (q. v.). The mineral elements of the bones are either dissolved (after all oily

matter is removed) in HCl and the remaining translucent cartilage rinsed, treated with lime (neutralized), rinsed again and then boiled down to glue as described above, or bones are used which, though free from fat, are not yet deprived of their mineral contents. (See BONE-FAT.) They are evaporated to dryness (which facilitates their pulverisation and the extraction of the glue), freed from all undesirable matter by centrifuges and finally ground to a meal in bone mills. This is boiled several times with H_2O and steam under pressure. The thin glue solution thus obtained is evaporated *in vacuo*, bleached by SO_2 and then treated as described above. The glues produced by the second method are less valuable as the long-continued boiling process decomposes the glutine on which the adhesive power depends.

The Germ. Pat. 144398 employs sulphurous acid instead of HCl for extracting the calcium phosphate from bones. This in itself is not a new process. The improvement consists in the use of an aqueous solution of SO_2 under pressure, a method which economizes the acid and prevents the formation of a crust of calcium sulphite which greatly hinders the necessary processes. See Germ. Pat. 166904, 168872, 177625, 178770, 187261.

Bone glue manufacturing plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.
Ernest Scott & Co., 2 Talbot Court, London E.C.

Bone Glue Plants:

Ernest Scott & Co., 2 Talbot Court, London E.C.

III. FISH GLUE.

Fish glue is produced from the scales and skins of fish, also from the heads and bones of cod by treatment with acid, rinsing, liming, and boiling with H_2O or steaming. The subsequent treatment does not differ from that of the other kinds of glue except perhaps that alum is frequently used for clearing.

The best kind of fish glue is isinglass, i. e. the purified and dried inner skin of the swim-bladder of the sturgeon.

Recently whale blubber has also been used in the preparation of glue. According to Germ. Pat. 131315 the blubber is cut up, freed from fat by cold pressing and the residue treated with benzene. By this method the whole of the oil is obtained, and at the same time the glutinous tissue is obtained dry and entirely free from fat, i. e. in a form especially well adapted for the manufacture of glue.

IV. LIQUID GLUE.

We mention the following receipts, from a vast number, for the preparation of liquid glue: 12 parts glue are warmed with 32 parts H_2O , two parts HCl and 3 parts zinc sulphate for 10—12 hours at a temperature of 80—85° C, or 6—12 parts acetic acid or the same amount of crude hydrochloric acid is added to a hot solution of 100 parts glue and H_2O . Another receipt is to dissolve 4 parts gelatine by heating with 4 parts strong acetic acid and then to add one part strong alcohol and a little alum. A very good receipt is this:—dissolve 100 parts glue in 110 parts boiling water and add 40 parts nitric acid of 35° Bé.

For further information see "GELATINE" and "MARINE GLUE" (under "ADHESIVES").

Isinglass Finings:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London SE.

Glue colours see "PAINTERS COLOURS".

Glutol (Glutoform) = Formaldehyde gelatine. Obtained by evaporating a solution of gelatine with one of formaldehyde or by placing leaves of gelatine

in formaldehyde solution, as a neutral substance quite insoluble in hot water, employed as an antiseptic powder.

Glutone. A nutritive preparation, soluble in water, obtained from gelatine. Recommended as a strengthening agent for invalids and convalescent patients.

Glycerine. $C_3H_5(OH)_3$. Does not occur free naturally, but in combination with fatty acids as glycerides in all fats, animal, and vegetable. Glycerine is prepared by saponifying fats and as a by-product in the manufacture of fatty acids and soaps.

The fats are generally decomposed with lime in copper autoclaves. H_2SO_4 is added to the aqueous glycerine which contains a little lime soap — to separate the fatty acids and lime, and the mixture neutralized with CaO and evaporated to the consistency of syrup *in vacuo*. Frequently the glycerine is only partially evaporated in pans and then passed on to special glycerine works.

When the fats are saponified with H_2SO_4 the aqueous glycerine must first be neutralized with CaO and separated from the $CaSO_4$ formed and then the above-mentioned method is carried out.

The purest glycerine is obtained by saponifying fats with steam. Originally only the raw material coming from stearine works was used, but for the last twenty years the manufacture of glycerine from the liquors obtained in soap boiling has become more general. Glycerine obtained by direct saponification with H_2SO_4 is called "distillation glycerine", and that obtained in stearine manufacture "saponification glycerine".

Concerning the preparation of glycerine from soap-liquors numerous details have become known though a good deal is still kept secret. The lye is cooled and filtered and concentrated until it contains 40 % glycerine. Chemical purification follows, chiefly by acidifying with HCl and filtering. Concentration *in vacuo* proceeds until the product contains 80 % glycerine. After cooling and again filtering crude glycerine is obtained, a product used for many purposes.

According to J. F. HINCKLEY (Chem. Ztg. 1907, Rep. 355) the proteids, soap and free alkali must be removed from the lower layers before concentration takes place. To accomplish this the liquors are cooled, the soaps which separate as a scum are removed, the solution neutralized with H_2SO_4 , the soapy matters precipitated with 0.5 % $FeSO_4$ and the whole filtered through filter presses.

According to a second process, the liquors are treated with 0.25 % CaO (in the form of milk of lime), well mixed by means of a current of air and allowed to settle. The clear solution is drawn off, made faintly acid with HCl , skimmed and treated with a small amount of $Al_2(SO_4)_3$ to precipitate the fatty acids. The liquor is allowed to stand, alkali is added in slight excess and the whole filtered through a filter press. The filtrate is concentrated *in vacuo* to 34° Bé. and the salts which separate are removed. The crude glycerine is then purified by distillation with steam.

According to the method of KREBITZ (Germ. Pat. 155108) glycerine is obtained as a clear 15 % solution (see SOAPS).

According to the Amer. Pat. 774172 glycerine is obtained by neutralizing the soap mother liquors with H_2SO_4 ; the insoluble fatty acids are precipitated with $Al_2(SO_4)_3$, Al -soaps filtered off, the liquid evaporated, mineral salts separated and $BaCl_2$ added, so that $BaSO_4$ and Ba -soaps are formed. Sufficient H_2SO_4 is now added to combine with the greater portion of the alkalies (held by the volatile fatty acids) while the fatty acids partly separate in an insoluble condition. They are filtered off with the $BaSO_4$, the filtrate is freed from H_2SO_4 and the remaining volatile fatty acids by boiling *in vacuo*, Na_2CO_3 is

added and the glycerine distilled off. — The practical value of this patent appears very problematical.

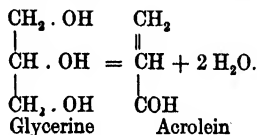
The decomposition of fats by ferments treated under "FATTY ACIDS" is also applicable to the preparation of glycerine as besides fatty acids an aqueous solution containing 40—50 % glycerine is obtained.

The Germ. Pat. 141703 has for its object the preparation of glycerine from distiller's wash, &c., the principle of the process (Chem. Ztg. 1903, 688) being as follows:— If distillers' wash (e. g. molasses), is distilled *in vacuo* at a temperature not exceeding 300°, the remainder after the removal of glycerine and water at 300° is liquid and runs off. The time necessary for the removal of the glycerine and water depends upon the thickness of the layer. The principal feature of the process is to allow the wash to run down the walls of a vessel in which the pressure is reduced, heated to not more than 300° C. from without in such a way that the temperature can be regulated. The wash enters in a liquid state without any mechanical assistance, passes through and leaves again, the process being continuous. First water and then glycerine is removed. The rate of flow must be regulated according to the size of the heating surfaces. The resulting steam is circulated and superheated so as to separate solid particles which may have been carried over, and to assist the escape of the glycerine from the anhydrous mass. The same process is also protected by the Germ. Pat. 125788 with the additional patent 147558.

In order to refine raw glycerine, which is of a dark colour, it is diluted and boiled with animal charcoal and then concentrated *in vacuo*. Chemically pure glycerine is obtained by distilling the diluted raw product with steam and distilling off the acid products which are volatile at 100—110°. The temperature is then gradually raised to 170° C (but not to 200° or decomposition will take place). The glycerine passes over with the superheated steam. By employing suitable coolers the products are separated into highly concentrated glycerine, very dilute glycerine and water. It is said to be advantageous to carry out the distillation *in vacuo*.

Glycerine when pure is a colourless, viscid liquid with a sweet taste. It is very hygroscopic, when exposed to low temperatures for a long time it gradually crystallizes. When ignited it burns with a blue flame S. G. 1.2647; 50% glycerine has a S. G. 1.1320. B. P. 290°. It gradually volatilizes at the ordinary temperature and can be entirely volatilized at 100—150°.

When glycerine is rapidly heated it decomposes with formation of acrolein-vapours, which have a penetrating smell and cause coughing. The decomposition of glycerine corresponds to the following equation:



The largest amount of glycerine is used in the manufacture of nitroglycerine and the explosives related to the latter (dynamite, &c.). Because it does not solidify in the cold, it is used to fill gasometers. It is used to make leather flexible as it does not change in the air, for printing rollers, for the preparation of elastic moulds, for making copying inks, stamp dyes, adhesives, blacking, &c.

The same properties in addition to the fact that it is harmless, tastes sweet, and is not attacked by ferments extends its use: It is used in extracting hops, as an addition to lemonades and jam, in preserving numerous eatables, in perfumery, tanning, dyeing, calico printing, dressing, in extracting pepsine, and as an ingredient in various medicines. Formic acid, mustard



SCOTT PATENT GLYCERINE RECOVERY PLANT

WITH MECHANICAL SALT-EXTRACTING AND CONVEYING ARRANGEMENT. CAPACITY 500 TONS OF SWEET LYE DAILY

(Edmund Scott & Co., Ltd., London)

Table (after LENZ), showing the S. G. and coefficient of refraction of aqueous glycerine-solutions.

Anhydrous glycerine	S. G. at 12—14° C.	Coeff. of refraction at 12.5—12.8° C	Anhydrous glycerine	S. G. at 12—14° C.	Coeff. of refraction at 12.5—12.8° C	Anhydrous glycerine	S. G. at 12—14° C.	Coeff. of refraction at 12.5—12.8° C
100	1.2691	1.4758	66	1.1764	1.4249	32	1.0825	1.3745
99	1.2664	1.4744	65	1.1733	1.4231	31	1.0798	1.3732
98	1.2637	1.4729	64	1.1702	1.4213	30	1.0771	1.3719
97	1.2610	1.4715	63	1.1671	1.4195	29	1.0744	1.3706
96	1.2584	1.4700	62	1.1640	1.4176	28	1.0716	1.3692
95	1.2557	1.4686	61	1.1616	1.4158	27	1.0689	1.3679
94	1.2531	1.4671	60	1.1582	1.4140	26	1.0663	1.3666
93	1.2504	1.4657	59	1.1556	1.4126	25	1.0635	1.3652
92	1.2478	1.4642	58	1.1530	1.4114	24	1.0608	1.3639
91	1.2451	1.4628	57	1.1505	1.4102	23	1.0580	1.3626
90	1.2425	1.4613	56	1.1480	1.4091	22	1.0553	1.3612
89	1.2398	1.4598	55	1.1455	1.4079	21	1.0525	1.3599
88	1.2372	1.4584	54	1.1430	1.4065	20	1.0498	1.3585
87	1.2345	1.4569	53	1.1403	1.4051	19	1.0471	1.3572
86	1.2318	1.4555	52	1.1375	1.4036	18	1.0446	1.3559
85	1.2292	1.4540	51	1.1348	1.4022	17	1.0422	1.3546
84	1.2265	1.4525	50	1.1320	1.4007	16	1.0398	1.3533
83	1.2238	1.4511	49	1.1293	1.3993	15	1.0374	1.3520
82	1.2212	1.4496	48	1.1265	1.3979	14	1.0349	1.3507
81	1.2185	1.4482	47	1.1238	1.3964	13	1.0323	1.3494
80	1.2159	1.4467	46	1.1210	1.3950	12	1.0297	1.3480
79	1.2122	1.4453	45	1.1183	1.3935	11	1.0271	1.3467
78	1.2106	1.4438	44	1.1155	1.3921	10	1.0245	1.3454
77	1.2079	1.4424	43	1.1127	1.3906	9	1.0221	1.3442
76	1.2042	1.4409	42	1.1100	1.3890	8	1.0196	1.3430
75	1.2016	1.4395	41	1.1072	1.3875	7	1.0172	1.3417
74	1.1999	1.4380	40	1.1045	1.3860	6	1.0147	1.3405
73	1.1973	1.4366	39	1.1017	1.3844	5	1.0123	1.3392
72	1.1945	1.4352	38	1.0989	1.3829	4	1.0098	1.3380
71	1.1918	1.4337	37	1.0962	1.3813	3	1.0074	1.3367
70	1.1889	1.4321	36	1.0934	1.3798	2	1.0049	1.3355
69	1.1858	1.4304	35	1.0907	1.3785	1	1.0025	1.3342
68	1.1826	1.4286	34	1.0880	1.3772	0	1.0000	1.3330
67	1.1795	1.4267	33	1.0852	1.3758			

oil and allyl alcohol are prepared from it. It is also used in glue and gelatine works and for many other purposes.

TEST. CRUDE GLYCERINE, DYNAMITE GLYCERINE and CHEMICALLY PURE GLYCERINE are the three main kinds known commercially. Crude glycerine is called according to its source saponification, distillation- or "lye"-glycerine. The first, obtained from stearine works in the process of saponifying with lime or magnesia, contains about $\frac{1}{2}$ % ash (containing a good deal of Ca or Mg), is light yellow to dark brown in colour and has a pure sweet taste. Usually of 28° Bé. When HCl is added it does not become cloudy; with acetic acid it gives a slight precipitate which slowly settles. — Distillation glycerine (saponification with H_2SO_4) is straw-coloured to dark wine-red, smells disagreeable and has an astringent taste. Ash, to 3.5 %; density 28° Bé.; 84—86 % glycerine. HCl turns it cloudy (fatty acids), acetic acid gives a thick precipitate. — The least pure glycerine is that obtained from the lye of soap works; it is light brown to brownish-red, has a salty taste, contains 10 % ash (mostly NaCl, also Na_2CO_3 , NaOH, &c.) and many organic impurities, like glue, rosin, &c. The concentration should be 34° Bé. (S. G. 1.3), glycerine 80—82 %.

Saponification and distillation glycerine are distinguished by their reaction with HCl and acetic acid, while lye glycerine is recognized by the amount of ash, high concentration and strong chlorine reaction.

The quantitative determination of impurities is best effected according to the "Hamburg method" (by the Hamburg Dynamite Co., Ltd. — Dynamit-Aktiengesellschaft Hamburg): In a small stoppered retort 20 g glycerine are heated to 100° for 8—10 hours, weighed and heated again for a few hours at the same temperature. The difference between the two weighings is generally only a few centigrammes; the total loss is water. 5 g glycerine are heated to 180° in a shallow platinum vessel until vapours are no longer given off. After continued heating a constant weight is generally obtained. The difference between the weight of crude glycerine and the sum of the weights of water and residue is reckoned as "PURE GLYCERINE". Finally the residue after ignition is determined. — Chemically pure glycerine should not contain more than 0.03 % ash and the same amount of organic impurities; for dynamite the sum of both should not exceed 0.35 %.

Inorganic substances are determined in the ash by the usual methods. The determination of chlorine should not be made directly but in the ash. Not infrequently oxalic acid is present which is determined by neutralization with NH_3 , acidifying with acetic acid and precipitating with CaCl_2 .

The percentage of glycerine, determined indirectly by the "Hamburg method", can be determined directly by calculating the S. G. or the coefficient of refraction. For both determinations consult the table by LENZ given above. When determining the S. G. of glycerine it must be free from air bubbles. This end is best attained with concentrated glycerine by warming in a retort with warm water a larger amount than is required and causing the bubbles to rise by shaking; after cooling the S. G. is determined in the usual way. In a very simple manner and with a few drops the contents of glycerine may be determined by means of a refractometer, but the coefficient found will be correct only when the temperatures given are closely observed.

Glycerine:

Domeier & Co., 8 Harp Lane, London E.C.

Glycerine Plant:

G. Scott & Son Ltd., 2 Talbot Court, London E.C.

Glycerine apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Glycerine Vacuum-Distilling Plant:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Glycerine phosphoric acid. $\text{C}_3\text{H}_5(\text{OH})_2 \cdot \text{O} \cdot \text{PO}(\text{OH})_2$. Formed by mixing P_2O_5 with glycerine. It is known only in aqueous solution. The commercial article is either a 20 % or a 50 % solution.

It is a dibasic acid. Some of its salts are used medicinally, and have a strong action on the nervous system. It is in this form that phosphorus is assimilated by the system.

The name TONOL is applied to preparations of the salts, Kalio-tonol for example being potassium glycerine phosphate.

Glycine see GLYCOCOLL and PHOTOGRAPHIC CHEMICALS.

Glycocoll (AMIDO-ACETIC ACID). $\text{CH}_2(\text{NH}_2) \cdot \text{COOH}$. Usually obtained from hippuric acid by heating with conc. HCl under a reflux condenser. The hippuric acid decomposes giving amido-acetic and benzoic acids. It may be prepared synthetically by the action of ammonia on monochloroacetic acid.

Large colourless crystals M. P. 236° , readily soluble in water, insoluble in alcohol and ether.

Glycollic acid (OXYACETIC ACID) $\text{CH}_2\text{OH} \cdot \text{COOH}$. It is formed when chloracetic acid is boiled with CaCO_3 , when glycerine is oxidized with Ag_2O or by the reduction of oxalic acid with Zn and H_2SO_4 .

It can be prepared electrolytically (Amer. Pat. 837083) by electrolyzing oxalic acid placed in the cathode chamber between lead electrodes. The oxalic acid is kept warm and the product of reduction dissolved in H_2SO_4 of such concentration as to neutralize the non-conducting action of the oxalic acid. It forms colourless, easily soluble needles, M. P. 80° , which have a very sour taste.

Gold. Au. Atomic weight = 197.2. This metal is almost always found native, and usually contains silver. More rarely it is found combined with other metals (e. g. mercury). Traces of gold are also found in many ores. Gold is, however, principally obtained from primary rocks and to a lesser extent from secondary rocks.

The gold washed down from the rocks is separated by water from the lighter mineral matter. The gold-containing rocks are treated with powerful water jets under a pressure of 4 to 5 atmospheres. The parts which are washed away pass through long channels in which the heavy gold sinks to the bottom, while the lighter mineral substances are carried on. Mercury is placed at the bottoms of these channels in order to catch the lightest and smallest particles of gold. From time to time the gold amalgam is removed and after purification distilled in retorts. The mercury distils over and the pure gold remains. If the gold is found embedded in quartz and other stones, these are crushed and treated with mercury. The mercury-gold alloy thus obtained, the so-called amalgam, is also heated in retorts. In such cases it is important that the stones or rocks should be thoroughly crushed in specially constructed machines or mills and the mercury intimately mixed with the crushed ore. If the gold is mixed with gravel or sand, it must be roasted if amalgamation is to follow. The process of roasting is not always an oxidizing, but may be a chlorinating process. In the latter case the "coating" which is so often formed and which hinders the amalgamation, is removed. The roasting is in this case carried on in presence of chlorine.

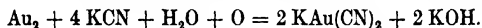
Mixed gold ores are not well adapted to the amalgamation process, and are usually smelted. The ore is smelted with lead, more rarely with copper: the gold and lead combine, and are afterwards separated by cupelling and refining. Compare SILVER. The extraction of gold by the chlorine and cyanide processes is important.

In the chlorine process the ore is roasted, moistened with H_2O and treated with chlorine. By extraction with H_2O the gold chloride produced is dissolved and the Au is precipitated generally with FeSO_4 . The Au is finally re-smelted with borax.

The cyanide process is of especial importance as it is possible to act directly on the unroasted ore. Potassium cyanide dissolves gold and gold sulphide. The ore is usually first treated with mercury, the cyanide being applied (after amalgamation) in the form of potassium cyanide solution (0.05–0.1 %). From the soluble potassium auri-cyanide thus obtained, the gold is precipitated in the FORREST method by means of zinc. This method is, however, only successful for solutions which are rich in potassium cyanide. Various modifications of this process have been proposed. The zinc-lead process introduced by BERRY has been used. Zinc filings are coated with lead by dipping into a 10 % solution of lead acetate and are then introduced into the vat.

W. SIEMENS' modification of the cyanide method is of great importance. This consists in separating the Au from the potassium auri cyanide by means of an electric current.

The steeping vat used consists of cylindrical casks of wood or steel plates provided with a filter composed of cocoa-nut matting over a wooden grating. The size of the cask up to 800 cbm is so chosen, that each can hold the one day's production. The number of casks depends on the amount of time necessary for steeping. As this usually takes 5—7 days, 5—7 casks are necessary. The result of the lixiviation is in accordance with the equation:—



The necessary oxygen is contained in the water and in the pulverized ore.

A method protected by the Germ. Pat. 138867 is to make use of raw product instead of pure KCN. This crude substance is obtained by the action of N on carbides. It can be used for the preparation of pure cyanide salts, though according to the above patent the crude substance serves the same purpose, and thus obviates the expense of refining. Compare CALCIUM COMPOUNDS.

The solution obtained after treatment with the cyanide flows through a wooden box divided into several compartments, for the purpose of electrolytical separation. In this iron plates are fitted as anodes and strips of lead foil as cathodes. A current of 2 volts and about 0.5 Amp. per square metre of electrode surface is used. An apparatus 7 m long, 1.5 m broad, and 1 m high consumes about 100 Amp. and reduces 50 cubic meters of solution in 24 hours. The gold separates on the lead cathodes in a dense form, which is removed from the apparatus at the end of each month and melted down. The lead bars containing gold to the extent of $\frac{1}{2}$ —10 % are refined by cupellation. The lead oxide is reduced to metal and rolled out into thin sheets.

The equipment of works for SIEMENS' cyanide process capable of treating 100 tons daily costs about £ 4500 excluding the building costs. The cost of labour 2/6. — to 3/ per ton.

Cyanide extraction is also now of special importance in the treatment of the slime and mud of the amalgamation residues. This mud which still contains gold is treated either by the DECONTAMINATION or by the FILTER PRESS PROCESS. In the first case the amalgamation residues are picked up by patent scoops and separated into sand and soft mud. The slime is then treated with lime whereby not only are the dissolved acids neutralized, but the fines particles are more easily separated. These particles are then finally recovered by extraction with a 0.01—0.02 % solution of KCN.

The second process mentioned consists in the simple process of putting the slime into filter presses and treating the cake first with weak KCN solution, then with H_2O and finally with compressed air. The DIEHL process is a modification of the usual cyanide treatment; it has proved very successful in treating tellurium gold ores. The extracting liquor is a mixture of bromine cyanide and potassium cyanide solution:— In this mixture, which corresponds to the formula $\text{KCN} + \text{BrCN} = \text{KBr} + 2 \text{CN}$, not only the CN of the KCN but another molecule of CN is set free so that a powerful gold solvent is formed. The ores which are to be treated by this process are pulverized in mills, then well roasted and separated into sand and slime. The sand is amalgamated, the residue of the amalgamation process is then mixed with the slime and treated further in the filter press with bromine cyanide and potassium cyanide.

A new method for treating auriferous mud deposits is that due to MOORE. A system of filter plates is let into the mud, which is drained thoroughly and treated with dilute KCN solution. After this it is washed and the cake is still further washed by drawing water through by suction. The cake is removed from the frame by air pressure.

Another process still remains to be mentioned viz. that of HENDRIX. In this process the precipitation of the gold is carried out in the same vat as the cyanide extraction. The ore is pulverized, KCN being added and then mixed with alkaline cyanide solution in a cask with a funnel-shaped bottom and a stirring apparatus. The liquid is thrown out by the apparatus and flows back into the holder over electrodes (amalgamated copper plates and lead-covered iron plates) with the result that the gold is separated by the electric current which passes during this treatment. In order to separate native gold from the Ag and the Cu with which it is always mixed it can be melted in a chlorine current, the two former metals being first acted upon by the chlorine. The separation is usually carried out by the wet method, e. g. by heating with HNO_3 . As however this treatment is only reliable when 2 to 3 times as much Ag as Au is present, gold which contains but little silver must be first melted together with more of the latter metal. An important process of separation is that known as the AFFINATION METHOD. This method is to heat with concentrated H_2SO_4 . The Ag and Cu are extracted while Au is not attacked. The method of ELECTROCHEMICAL REFINING is however cheaper than the affination process and causes less loss of silver. It is carried out by the MOEBIUS method which in a very short time has proved to be practical and trustworthy. HNO_3 in this case serves as electrolyte into which the plates of silver containing gold are hung. The Au attaches itself to the anode, and all the other metals pass with the Ag into solution. The silver alone then forms crystals on the sheet silver cathodes. The alloy to be separated must be at least 950 parts fine. The most unfavourable results are obtained when a too large percentage of Cu is present, as then this metal separates on the cathode with the Ag.

Recently a weak slightly acid AgNO_3 solution has been used as electrolyte in place of HNO_3 . The work is carried out with about 1.5 volt and a current density of 350 Amp. per 1 sq. m. The Ag obtained by the electrolytical method is, after melting, 999 parts fine. The anode plate are consumed in about 40 hours; the residual gold mud falls into the cotton bags in which they are hung. From time to time the gold slime is taken out, boiled with HNO_3 to remove the last traces of Ag, and finally melted down, then yielding a gold of 999 degrees of fineness.

Pure gold is soft and the most ductile of all metals. The thinnest gold leaf has a blue green lustre. Its specific gravity at 17.5° is 19.33, and its melting point according to the most recent investigation of HOLBORN and DAY is $1063.5\text{--}1064^\circ\text{C}$. This metal is soluble in chlorine water and aqua regia and is acted upon by caustic alkalies and by fused alkaline nitrates. Considerable interest has recently been excited by an English method for obtaining, on a commercial scale, the gold contained in sea-water. Similar reports have often indeed before this been spread abroad, but without receiving any serious consideration from the scientific world. In the present case however the matter appears in quite another light, for no less a personage than SIR WILLIAM RAMSAY is quoted as the prime-mover in the enterprise. It is therefore with the greatest interest that scientists and practical men await further reports on this subject. RAMSAY gives 0.065 g Au per ton of sea-water as the average yield.

Gold has also of late become known in colloidal form so that it appears to be in a state of solution. Compare COLLAURINE and COLLOIDAL BODIES. According to VANINO and ZSIGMONDY a red gold colloid is obtained by the reduction of dilute solutions of gold salts with formaldehyde, a blue gold hydrosol by the reduction of perfectly neutral AuCl_3 solution (1 : 1000) with hydrazine hydrate (1 : 2000) or still better with phenyl hydrazine hydrochloride. A red solution of gold is formed according to KUSPERT by the action of sodium silicate containing formaldehyde on AuCl_3 .

Pure gold is seldom used on account of its softness. Pure gold in the form

of leaf is used for gold plating and in dentistry. When alloyed it is used for coinage, ornaments, &c. and preparations of gold are used in photography and for the painting of glass and porcelain.

Gold (LIQUID). Dark brown, rather viscid liquid of aromatic smell, used for painting China. It is applied with a brush, allowed to dry and then burnt on. It contains about 10 % gold (as chloride), resins, lavender oil and bismuth; the details of the manufacture are kept secret. The use of rhodium as an addition to these preparations is interesting; it has been found that the presence of rhodium insures the required resistance after burning.

Gold Alloys. In consequence of its softness and to prevent rapid depreciation, gold is always used in the form of an alloy. The metals in question are generally melted in graphite vessels, and graphite rods are used for stirring.

The gold contained in alloys is expressed in carats. Pure gold contains 24 carat; so 14 carat gold for instance contains 14 parts by weight of gold, and 10 parts of some other metal. In Germany the gold contained must be expressed in $\frac{1}{1000}$, so 14 carat gold contains $\frac{14}{24} \times 1000 = 585$ approx. of fine gold.

Alloys of gold and silver are called white caratings, of copper, red and with both metals mixed caratings. It is possible to vary the colour from brilliant red to pale yellow. Other colours are obtained by the use of other metals, for instance grey gold consists of 30 Au, 3 Ag and 2 steel-dust; blue gold of 1—3 Au and 1 steel; green gold of 750 Au, 125 Ag, and 125 Cd. Other colours can be obtained by caustics. Very poor trinkets are treated with H_2SO_4 or HNO_3 which removes Ag or Cu from the surface making the gold more visible. Bluish black ornaments of gold consists of about 90 % Cu, 10 % Au and a little Sb; the dark-blue surface is obtained by the action of a boiling solution of $CuSO_4$ and alum.

German coins are almost exclusively made of gold containing 900 parts per 1000; jewellery of gold containing 200 to 800 parts per 1000. It should be noticed that real gold bronze (shell gold, artists' gold) is pure gold and not an alloy; it is made from the residues of gold-beating works or obtained as a precipitate from a gold solution.

Gold bronze see "GOLD ALLOYS" and "COPPER ALLOYS".

Gold colours. Only one gold preparation is used as a colour, gold purple or purple of Cassius. The composition of purple of Cassius is not quite certain: While formerly it was thought to be gold stannate it is now regarded as stannic acid containing very fine particles of metallic gold. There are numerous prescriptions for preparing purple of Cassius. For instance a solution of stannous chloride is mixed with so much ferric chloride solution that the mixture appears green. This is poured drop by drop with constant stirring into a very dilute (about 2 %) solution of gold chloride: after some time purple of Cassius settles to the bottom.

It is not used as a paint, but is exclusively employed to colour glass purple red (see "GLASS COLOURS" and also in painting glass and China.

It is brownish-red to purple, a very light and fine powder, containing 20—40 % Au. Usually, however, preparations containing less gold are used.

Gold compounds. Gold chloride and sodium auri-chloride are the only compounds of Au which are of industrial importance.

1. **GOLD CHLORIDE.** $AuCl_3$. This compound is formed by dissolving Au in aqua regia. It forms a dark brown, crystalline substance which readily

deliquesces. It dissolves in H_2O , alcohol, ether, and various essential oils. The solution colours organic substances (e. g. skin, paper, linen, wool, &c.) red and has a strong caustic action. The solution of AuCl_3 can be decomposed and the gold separated by many substances such as FeSO_4 , formic acid, metals, &c. It is used in glass and porcelain painting, in photography, for the manufacture of purple of Cassius and of fine gold for gilding, and as a medicine.

2. SODIUM AURI-CHLORIDE. $\text{NaAuCl}_4 + 2 \text{H}_2\text{O}$. Obtained by concentrating a mixture of AuCl_3 and NaCl solutions. It forms orange yellow crystals and is employed for the same purposes as gold chloride particularly for toning the paper positives in photography. This substance contains about half as much gold as AuCl_3 .

Gold Compounds:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Gold leaf see "FOILS, METALLIC".

Genorol. This is only an approximately pure sanatol. It is used for treatment of gonorrhoea.

Goudron. A by-product in the distillation of brown coal-tar. The resins are freed from acid by rinsing in water and distilling with varying amounts of creosote oil; according to the proportions of the ingredients and according to the length (of time) of the distillation goudron or the so-called German or artificial asphalt is obtained. Goudron is also prepared from natural asphalt by melting asphalt-stone with mineral-tar. Finally the tarry substances left in refining mineral oils (q. v.), (i. e. in the treatment with H_2SO_4 and rinsing with H_2O) is used to prepare goudron.

Goudron is used in liquid asphaltting, for insulating (electrical), and for painting damp walls and basements.

Graphite (PLUMBAGO, BLACK LEAD). An allotropic form of C, occurring naturally as crystals. Graphite is formed when the carbon dissolved in cast iron crystallizes out, by the decomposition of cyanogen compounds, &c. &c.

Natural graphite must be purified before it can be used. This is done mechanically by rinsing and then chemically by boiling in H_2SO_4 and HNO_3 (to remove Fe), or by warming with KClO_3 and dilute H_2SO_4 . Finally the graphite is rinsed in H_2O and dried at a moderate heat. SiO_2 when present is removed by a treatment with $\text{NaF} + \text{H}_2\text{SO}_4$.

The Germ. Pat. 161722 protects a process of obtaining graphite leaves from the less valuable fine grained graphite. The method consists in subjecting the graphite, either alone or with some cementing agent (e. g. resin powder, bitumen, paraffin, &c.), to high pressure between rollers.

Graphite is iron black to steel black, shining, infusible, non-volatile, insoluble in all solvents, very difficult to burn, S. G. 2.1—2.3. It is used in the manufacture of pencils, for making crucibles, as a preventive of rust, to make the moulds used in electrotyping conductors, &c.

Recently artificial graphite has become important. According to the Amer. Pat. 568323 it is obtained as a by-product in the manufacture of silicon carbide (see "CARBORUNDUM") a greater yield of graphite resulting from impure carbon or such which contains iron. ACHESON, the inventor, uses carborundum furnaces to prepare artificial graphite and graphite electrodes. The latter are made by moulding a mixture of petroleum coke and pitch (containing a little silicic acid or iron oxide to form carbide) into the required shape and heating them in the furnace to a temperature above that at which Fe and SiO_2 volatilize. Graphite, intended for making paint, crucibles, &c., is made from anthracite.

The manufacture of graphite as largely carried out in America (Niagara) by the ACHESON method is very simple. The carbon is placed in rectangular firebrick vessels 9 m long, the walls of which are lined with carborundum. At the ends are large carbon plates by means of which the current passes through the contents of the furnace. The mixture consists of 3 to 3.5 parts of carbon or coarse anthracite covered with small coal. This is heated by an alternating current (210 volts, 1400 to 1500 amp.). After some hours the strength is raised to 3600 amp. and the temperature necessary for the formation of graphite is attained. After 24 hours, the conductivity of the mass increases, the current rises to 9000 amp., and the E. M. F. falls to 80 volts. The power developed (1000 H. P.) is sufficient to convert the whole into graphite. If the original carbon contains 5—10 % ash, all but about 0.5 % is so converted. If the carbon introduced is previously moulded, the resulting graphite is of the same form. In this way plates up to 90 cm long and 5 cm × 20 cm in section, or cylindrical rods up to 1 m long × 5 cm diameter can be obtained. These electrodes are very resistant to the action of chemicals, and are easier to work than the ordinary carbons. The amorphous graphite can easily be ground and the powder used for the manufacture of pencils.

According to Germ. Pat. 112416 CO_2 + CO are passed over carbide heated to red heat, or a mixture of acetylene, CO_2 and CO are led through a red hot tube. The carbide, CO_2 and CO all decompose. Such a mixture can also be exploded in some other way, but in each case decomposition occurs in the sense of the following equations

1. $\text{C}_2\text{H}_2 + \text{CO} = 3\text{C} + \text{H}_2\text{O}$
2. $2\text{C}_2\text{H}_2 + \text{CO}_2 = 5\text{C} + 2\text{H}_2\text{O}$.

When carbide instead of acetylene is used these equations hold, except that CaO is formed instead of water. If acetylene is combined with CO and CO_2 an amorphous C-containing soot of excellent covering properties is obtained. On the other hand when carbide is used, with a mixture of CO + CO_2 the carbon separates as graphite. This graphite after it is separated from the other products of the reaction by mechanical and chemical processes is at least as good as that obtained by ACHESON's method.

According to Supplement to Germ. Pat. 174846 graphite is obtained from carbide by the action of substances which liberate carbon. The reaction takes place by heating, or under pressure, the substances used being Cl, Br, I, N, P, As, HCl, HBr, HI, H_2S , NH_3 , organic halogen — sulphur — or nitrogen-compounds or reducible compounds of the alkalis, alkaline earths, and earths.

There are other methods for the preparation of graphite but they are of less importance.

According to ACHESON, stable graphite emulsions can be obtained by grinding graphite in an aqueous solution of ammonia and tannic acid. The emulsion can be mixed with water and mineral oils without the separation of graphite, and can be used as a lubricant for machinery.

Cf. RETORT GRAPHITE.

Black lead (Graphite):

Aflenzcr Grafit- und Talksteingewerkschaft G. m. b. H., Aflenz (Steiermark).
Humann & Teisler, Dohna Bez. Dresden, Germany.

Grey lime see CALCIUM ACETATE.

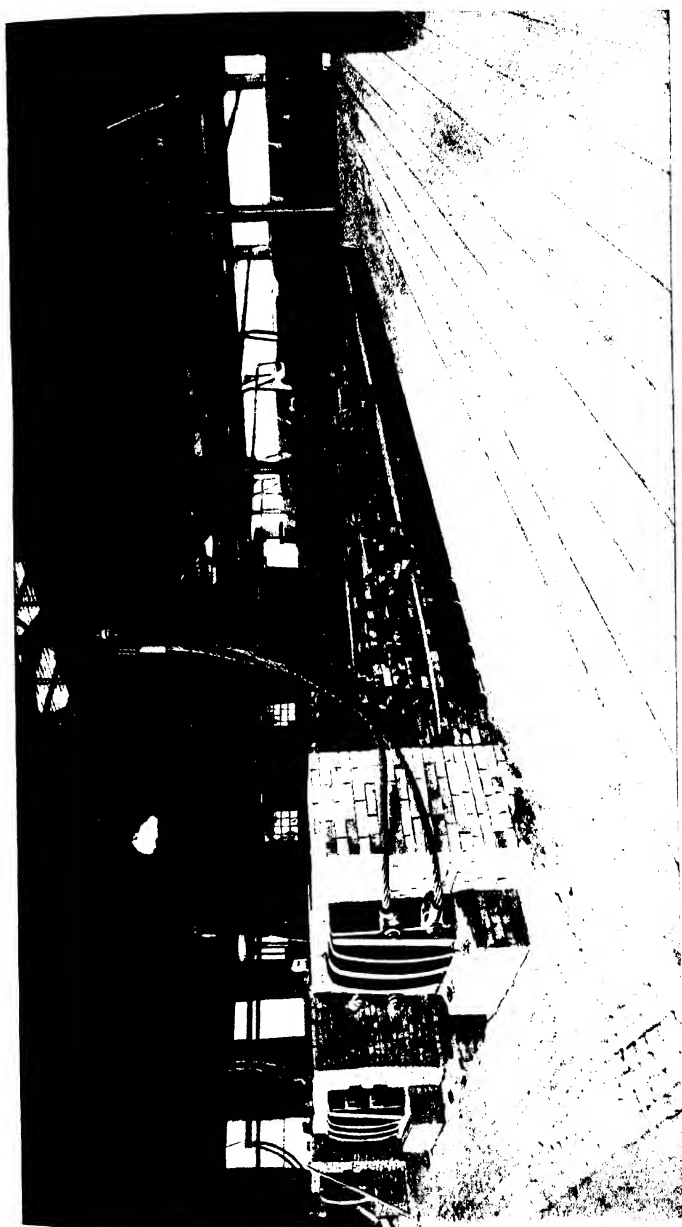
Grignard's reaction see "REAGENTS and REACTIONS".

Grinding mills see „MILLS“.

Grinding or polishing Materials see „POLISHING OR GRINDING MATERIALS“.

Grinding or polishing materials:

Cannings, Great Hampton St., Birmingham.



ELECTRIC GRAPHITIZING FURNACES, NIAGARA (International Adheson Graphite Co.)

Griserine. A mixture of LORENTINE (q. v.) with 6.75 % NaHCO_3 . Recommended as an internal antiseptic in cases of tuberculosis and various other diseases. Opinions as to its value are contradictory.

Guaiaicol. (METHYL CATECHOL.) $\text{C}_6\text{H}_4(\text{OH})(\text{OCH}_3)$ (1 : 2). Chief constituent of beech-wood creosote. In order to obtain it beech-tar is distilled and the fraction coming over between 200 and 205° is collected. The guaiaicol is separated by washing with strong NH_3 and then adding an alcoholic solution of KOH , when the potassium guaicolate is formed. This is washed with ether, recrystallized from alcohol and decomposed with dilute H_2SO_4 . It is again purified and may be obtained in crystals by allowing its solution in petroleum ether to evaporate.

It may be obtained synthetically (Germ. Pat. 95339) by diazotizing o-anisidine and distilling the solution acidified with H_2SO_4 in a current of steam.

It is a clear, colourless or pale-yellow oily liquid (or colourless crystals M. P. 28.5°). B. P. 200—205°. Soluble in about 60 parts of water, 7 parts glycerine, easily soluble in alcohol, ether, chloroform and carbon bisulphide.

Because of its specific action on the tubercle bacillus it is used largely in the treatment of tuberculosis.

Guaiaicol carbonate see "DUOTAL".

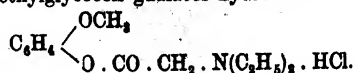
Guaiaicum resin. Occurs in the wood of the West Indian guaiaicum tree (*Guaiaicum officinale*). The most valued kind (grains or drops) exudes spontaneously from the tree, but the resin in lumps is obtained by heating the wood or by extracting it with boiling water.

Greenish or reddish-brown resin with a peculiar smell, S. G. 1.2; B. P. 85°; acid number (direct estimation) 20—45; acetyl acid number 13—23; acetyl-ester number 120—150; acetyl saponification number 163—193; methyl number 73—84; ash 2—10 %. Solubility:—In alcohol at least 80 %; in water 3—5 %; in petroleum ether 0.06—10.0 %; in ether and benzene 20—90 %; in CS_2 , 12—38 %.

In air it turns first green and then blue. A characteristic reaction is the change in colour of a solution from green to blue on the addition of H_2O_2 . It is used in medicine (see GUAIAICOL).

The so-called perfumed guaiaicum or Peru guaiaicum is of an entirely different nature and of different properties.

Guaiaisanol. Diethylglycocol guaiaicol hydrochloride



It is prepared by the action of chloroacetyl chloride on guaiaicol and treatment of the product so obtained with diethylamine.

White prisms M. P. 184°, very easily soluble in water, sparingly soluble in alcohol, insoluble in ether. In the body it is decomposed with formation of guaiaicol, and since it has no injurious action on the mucous membrane and is easily absorbed, it is used as a subcutaneous injection and is also prescribed for internal use in tuberculosis of the lungs, larynx, and intestines. Dose 3—12 g daily or subcutaneously 3—4 g in strong aqueous solution.

Guanó. The decomposed excrement of sea-birds, a light or dark brown, earthy or dense substance with a strong ammoniacal smell. Found in Peru, on the coast of South-West Africa, in Australia, Egypt and on various islands. Guanó is one of the best manures, containing on an average 10—15 % phosphoric acid. The guanó formerly found contained so much

organic substance that the amount of nitrogen was approximately equal to that of phosphoric acid. At present, however, the nitrogen of the various kinds on the market has sunk to about one half of this or even less.

The so-called PHOSPHATIC GUANOS, found on the islands of the Atlantic ocean and the South Sea differ from ordinary guano. The organic substance has been dissolved or decomposed by water (storm floods and rains). They form a brown powdery substance with from 32—40 % phosphoric acid.

See "MANURES, ARTIFICIAL". To facilitate the use of guanos as manure they are frequently treated with H_2SO_4 , sieved, broken up and made of an average composition by mixing different kinds.

Guignet's green see "CHROME COLOURS".

Gum-resins. Mixtures of gums and resins obtained by the hardening of the juice of different plants.

1. GUM AMMONIA. A gum obtained from a Persian umbelliferous plant. It forms yellowish-white to brownish-red grains or lumps which burn with a smoky flame. It is used medicinally and as a constituent of many adhesives. Numbers:— Acid (direct estimation) 55—135; ester 60—100; saponification (hot) 145—235; saponification (total) 99—155; methyl 8.6—11; ash 1—10 %. Loss at 100° 2—15 %. Only partially soluble in all indifferent solvents. Water dissolves 20 %, alcohol up to 90 %.

2. EUPHORBIA. Dried juice of an EUPHORBIA found in Morocco; it forms yellowish or brownish, translucent brittle pieces of the size of hazelnuts, which are hollow and have a burning taste. The dust has an irritating effect on the mucous membranes. Used externally only.

See also GALBANUM, CAOUTCHOUC and GUTTA-FERCHA. Other gum-resins such as myrrh, opoponax, &c. are of importance only medicinally.

Gums. Gums are vegetable substances which swell up in water in which some are soluble, insoluble in alcohol and other resin solvents. According to their chief constituents three kinds are distinguished, those containing 1. arabine, 2. cerasine and 3. bassorine.

1. GUMS CONTAINING ARABINE. The most important representative is gum arabic (*gummi arabicum*), also called gum acacia. It is the dried juice of several kinds of African acacia. The two sorts, viz. the true gum arabic (CORDOFAN GUM) and Senegal gum differ only slightly as they come from the same tree though from different countries.

Pale yellow to brown red-pieces of varying size; completely soluble in H_2O . S. G. (at 15° C) 1.487. Much used as an adhesive, ingredient of inks, paints, &c. The substitutes, like Cape gum and Australian gum are not entirely equivalent to real gum arabic.

TEST. In consequence of its high price gum arabic is often adulterated. The adulterations are insoluble cherry resin, dextrine, and (very frequently) Senegal gum.

Gum arabic occurs as irregular transparent glassy pieces, varying from the size of lentils to that of walnuts. It is brittle, white or yellow to brown, marked on the surface with cuts, &c., easily broken up and powdered. It does not become moist when exposed to the air; when broken it exhibits a glittering conchoidal fracture and with cold H_2O forms a nearly clear solution which is thick, slimy and viscous, draws out in threads a little, though it is not tough nor jelly-like; it is slightly opalescent, very adhesive and has a slightly acid reaction. When chewed gum arabic breaks and dissolves easily in the mouth with a faint slimy taste.

Senegal gum forms larger, more transparent pieces, either colourless, light yellow to reddish or white at the surface, looking like ground glass, trans-

parent and shiny in the interior. Cracks penetrating to the interior are less frequent than in gum arabic. On the other hand it has large air-bubbles. While the exterior is rough and not very lustrous the fracture is conchoidal and very bright. The pieces are usually long, straight, twisted, cylindrical or worm-like, but round pieces and frequently mulberry-like pieces composed of many small drops also occur.

These characteristics are sufficient to distinguish between gum arabic and Senegal gum if the pieces are not ground. This will also be sufficient to show the absence or presence of other gums. Another point of distinction between Arabian and Senegal gum and gum arabic is that the former gradually becomes moist in the air. It also becomes only slightly cloudy with mercurous nitrate and becomes very thick on the addition of borax. It is less soluble in H_2O ; the solution is more slimy and gelatinous and easily coagulates when treated with many chemicals.

2. GUMS CONTAINING CERASINE. One of the main representatives of these is cherry gum, forming spherical and kidney-shaped pieces yellow to red in colour, gathered from stone fruit trees like plum, cherry, apricot, &c.

3. GUMS CONTAINING BASSORINE. One of these is tragacanth obtained from the various kinds of *ASTRAGALUS* of Persia, Syria and Kurdistan. Tragacanth exudes from incisions in the bark and hardens in a few days.

White or yellow to brown pieces, tasteless, tough, difficult to powder, swells in H_2O . The powder forms an opalescent solution with water. It is used industrially for thickening colours, in cloth dressing, in confectionery work, &c. It is also used in the preparation of medicines.

TEST. Gum tragacanth is comparatively easily identified by the physical properties already mentioned: Odourless and tasteless, translucent, horny, and so tough that it is powdered only with difficulty. In H_2O only a very small portion really dissolves; but it swells to a slime which though not sticky is a good adhesive which can be mixed with a large quantity of water.

British Gums:

H. Preston & Co., Bury, Lancs.

Gun cotton (Nitrocellulose, trinitrocellulose; hexanitrocellulose; pyroxyline) is $n C_6H_7O_2(O \cdot NO_2)_3$ or $C_{12}H_{14}O_4(O \cdot NO_2)_4$.

Gun cotton is obtained by nitrating cotton with a mixture of nitric and sulphuric acids (see "NITRATION"). The cotton must be pure freed from fat by treatment with dilute Na_2CO_3 solution, rinsed with H_2O , then treated with warm dilute HNO_3 , rinsed again and dried at about $110^\circ C$. Finally before nitrating it is cut into threads by a machine. The acid used for nitrating consists of 1 part HNO_3 (S. G. 1.516) and 3 parts H_2SO_4 (S. G. 1.842). Mixing and transferring of the nitrating acid to the nitrating vessels is done as in the case of nitroglycerine (q. v.). Formerly nitration was carried out exclusively in square cast iron vessels, cooled by H_2O , into which the cotton was dipped with an iron fork, stirred about and after a certain time pressed out on a grid above the vessel. At present the nitration is also done in lead vessels preferably fitted with a centrifuge machine. The raw gun cotton is washed repeatedly in vats with cold and warm H_2O and then freed from the last traces of acid by boiling with H_2O (formerly CaO , Na_2CO_3 , precipitated chalk were used) and finally centrifuged. Then the gun cotton is torn up in tearing mills (see "PAPER"), centrifuged again and dried on warm plates at $40-50^\circ$. The latter process is dangerous for various reasons, as gun cotton while drying frequently becomes electric. On this account it is frequently treated with alcohol instead of being dried in air (i. e. if the kind of gun cotton or its intended use permits this to be done, as for example in the manufacture of certain kinds of smokeless powder). The water contained in the gun cotton is by this method

replaced by strong alcohol. The gun cotton is impregnated with alcohol in closed vessels by means of air under a pressure of several atmospheres. The excess of alcohol is afterwards removed by hydraulic presses.

According to the Germ. Pat. 150319 the nitrocellulose (gun cotton, collodion wool, &c.) in order to remove rapidly all acids and to render it stable is treated with dry superheated steam in centrifuges. In this way the unstable compounds are decomposed and removed with the condensed water. After steaming the nitrocellulose is rinsed first with hot and then with cold H_2O in the centrifuge.

The English Pat. 5126 (1904) prepares nitrocellulose by dissolving cotton at a temperature of $2-3^{\circ}C$ in 5 parts concentrated H_2SO_4 with about 2-3 % NH_4NO_3 , afterwards adding 2 parts HNO_3 . The nitrocellulose is precipitated in hard sandy lumps. After a few hours, when the substance has become hard, it is rinsed in a filter press. Nitrocellulose thus obtained forms a fine slowly burning powder which does not explode readily.

For military purposes gun cotton is mainly used in the compressed state. In this case the centrifuged, though still moist gun cotton is at first placed in a lever press and then an hydraulic press, where a cylindrical or prismatic form is imparted to it by a pressure of 600 atm.

Granular gun cotton is obtained by moulding the pulp — when leaving the tearing machines — into plates and cutting them up. The grains are dipped into acetic acid for a moment in order to give them a hard surface.

Gun cotton as far as appearance goes, looks just like cotton. It is not quite so white and is a little harder to the touch. It is insoluble in H_2O , alcohol and acetic acid, soluble in acetic ether and nitrobenzene, less readily in ether and acetone. When loose, dry gun cotton explodes by friction, by a sudden blow, and when strongly heated. It burns so rapidly when heated that gunpowder placed beneath it does not catch fire. When compressed or moist, hammering &c. has no effect and lighting causes slow burning without explosion. To insure explosion in this state a little dry gun cotton is placed inside and the latter exploded by mercury fulminate. On explosion 1 kg gun cotton produces about 850 l of gas (measured cold); the temperature of combustion is calculated to be about $6000^{\circ}C$.

Gun cotton is used to fill torpedoes, mines and shells, also for rock blasting. The greater part is, however, used in the manufacture of smokeless powders, see "GUNPOWDER".

Gun Cotton:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin.

Gun Cotton apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Gun Cotton drying plant:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Gunpowder.

1. BLACK POWDER.

Mixtures of salpêtre, carbon and sulphur in varying proportions, the average ratios being 74-78 % salpêtre, 9-12.5 % sulphur and 10-16 % carbon. These proportions (average 75 % KNO_3 , 10 % S and 15 % C) are, however, observed only in the old military powder and perhaps in sporting powder, while in blasting powder greater variations occur, the ratios being between 60 and 70 % KNO_3 , 10 and 15 % S, 12 and 21.5 % C.

As salpêtre, KNO_3 is the only kind used, $NaNO_3$ being too hygroscopic. The salpêtre is refined by dissolving it in glue solution. The foam appearing on the surface is removed, the liquor evaporated to 45° Bé and finally cooled in crystallizing vats and constantly stirred.

This KNO_3 in the form of a crystalline powder is after draining washed with a stream of water and then dried on grids and finally in drying pans or centrifuges.

The only kind of S used is bar sulphur; sulphur crystals are useless as they contain SO_2 . The bar sulphur is purified either by distillation or by melting and then filtering through gauze.

The carbon should be porous and easily combustible and should burn rapidly without leaving much ash. These conditions are best fulfilled by the carbon of various foliage trees, especially by black alder, alder, hazel, willow; also poplar, lime, vine, taxus, &c. are used. Carbonisation is carried out in closed iron cylinders; the product is all the more inflammable, that is better adapted for the manufacture of gun powder, the lower the temperature of carbonisation. At 270°C the reddish to red-brown, so-called red carbon is formed, while at 340° black carbon is obtained. If the temperature rises above 430°C the product is useless for the manufacture of gunpowder.

The ingredients of black powder are ground in barrels, ball- or vertical mills. The salpêtre is ground alone or with the carbon, and the sulphur together with carbon, then the mixtures are placed in large leather drums and there mixed by the aid of balls of *Lignum vitae*. Frequently the mixing is done by introducing steam, in which case the resulting pulp is dried in pans. If the grinding is done in vertical mills the mixing follows, the mixture being moistened with 2–4 % H_2O .

The powder cake thus obtained is ground in crushing machines and then made compact by rolling or more often by hydraulic pressure. The pressure is gradually increased to 25–30 kg per square centimetre. The compact powder cake must now be granulated before drying, a process which is carried out in machines working with sieves or marked rollers. The powder grains are sorted according to size and then dried on gratings. Finally the powder is polished by allowing it to rotate in leather drums (frequently graphite is added). The polished powder is dusted and sorted again.

The prismatic powder used for cannons, is obtained by compressing the moist powder cake into moulds by means of hydraulic pressure.

In spite of its marked hygroscopic property an attempt has been made recently to replace the expensive KNO_3 by NaNO_3 which is cheaper and contains more oxygen.

According to the English Pat. 7626 (1901) very gaseous coal is used with NaNO_3 and sulphur, gasoline and hot H_2O being added during the process (?). According to the Russian Priv. 7541 a black powder consists of 69 parts NaNO_3 , 5 parts KNO_3 , 10 parts S, 15 parts coal-tar and 1 part potassium-bichromate; the tar prevents it from becoming damp.

II. SMOKELESS POWDER.

The smokeless kinds of powder owe their origin to the demand for a powder which should surpass the black variety in strength, produce in smaller guns a kinetic energy at least equal to that formerly obtained in larger weapons, give the projectiles a very flat trajectory and very long range, and finally do away with or minimize as far as possible the tell-tale smoke of black powder.

The smokeless powders now in use can be divided into three classes, viz. guncotton powder, nitroglycerine powder and picrate powder.

In the first group guncotton (q. v.), nitrated as perfectly as possible, is cut in ray mills, rinsed, dried and dissolved in acetone or acetic acid or for preference in a mixture of alcohol and ether. A gelatinous substance is formed which is well kneaded mechanically and then rolled out into thin translucent leaves. The leaves are dried and then cut up into square pieces. Sometimes lentil-shaped pieces are punched from the leaves (and the waste re-rolled &c.). The edges of the pieces or grains after another drying are polished by rolling

and graphiting. Details of the process are kept secret. There are many modifications of the method. Plastomenite is obtained by dissolving gun cotton or wood-nitrocellulose in nitrotoluenes with addition of $\text{Ba}(\text{NO}_3)_2$ and $\text{K}_2\text{Cr}_2\text{O}_7$.

The main constituent of the smokeless powders of the second group is BLASTING GELATINE (see "DYNAMITE"). Collodion wool (q. v.) is mixed with nitroglycerine (q. v.) *in vacuo* at $6-8^\circ\text{C}$. Excess of nitroglycerine is pressed out or removed by centrifuging and the mixture itself gradually heated (finally under water) to 60 to 90°C when it becomes gelatinous. The water is removed by pressure at the same temperature and the remainder rolled out into sheets of the thickness of paper, which are either cut into squares or formed into cubes of $9.5-20$ mm edge by rolling a number of sheets together between warm rollers and then cutting. This form of smokeless cubical powder is called BALLISTITE. FILITE, of the same composition, consists of threads square in cross section, $0.5-1$ mm deep. In preparing CORDITE, guncotton dissolved in acetone and then mixed with nitroglycerine is used in place of collodion wool; addition of graphite &c. makes the mixture less explosive. — According to the Germ. Pat. 141314 hexa-nitro-cellulose is dissolved in hot benzene and nitroglycerine added; another method involves the use of a mixture of hexa-nitro-cellulose and tri-nitrobenzene by placing it in hot benzene; the whole mass is made amorphous and is then dissolved in nitroglycerine.

Picrate powder is the name given to powders in which the main constituent is the K- or NH_4 -salt of picric acid. These highly explosive salts, crystallizing in yellow needles, are moistened and mixed with KNO_3 (frequently also with carbon). The cake is pressed hydraulically, ground, sorted through sieves, polished, and dried. The derivatives of tri-nitro-cresol $\text{C}_7\text{H}_4(\text{OH})(\text{NO}_2)_3$, homologous with picric acid, should also be mentioned as picrate powders. They are used more for blasting purposes than as gunpowders. CRESYLITE e. g. is fused tri-nitro-cresol and cerasite its ammonium salt.

Numberless other powders have not up to the present proved to be of any practical value.

Gunpowder:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin.

Machines for manufacturing Ammunition:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Guttapercha. The latex of several South Asiatic trees of the *Sapotaceae* family, dried and kneaded with water. It is obtained by tapping the trees. The juice which cokes very soon after it runs out is kneaded together into blocks or leaves of $10-20$ kg weight and is then known as crude guttapercha. Recently Prof. JUNGLEISCH's method of not taking the juice from the trunk but from other parts and more especially by mechanical means from the leaves, is becoming more usual. The parts of the plant are crushed to a powder by machinery; when this powder is boiled in sea-water guttapercha free from all impurities separates in thin layers. By this method the guttapercha trees are saved, and the product thus obtained fetches a high price in consequence of its purity.

The crude guttapercha containing pieces of wood and bark, small stones, &c. is cut into pieces or torn up and softened by boiling water. It is treated with hot water in a tearing machine (see "PAPER") and so is freed from all impurities. Finally the pieces and shreds are pressed in the form of a pulp through fine sieves and then kneaded together again between rollers which at the same time press out all water and air.

Pure guttapercha is a leathery substance, of a greyish white colour, much like caoutchouc. It is inelastic and tough at the ordinary temperature, plastic

and soft when warmed. Easily soluble in chloroform and carbon bisulphide, in warm benzene and turpentine oil, slightly soluble in absolute alcohol. It oxidizes gradually in the air; sunlight has a decomposing action upon it.

Guttapercha, like caoutchouc (q. v.) can be vulcanised. It is mixed with sulphur, pressed into the required shape and then heated. The process of vulcanising is, however, rarely carried out. By prolonged vulcanizing with much sulphur and the addition of chalk, plaster of Paris, colours, &c., hard rubber is obtained (ebonite, horny guttapercha), a similar substance to the product obtained from caoutchouc by a like process.

Many attempts have been made to prepare guttapercha substitutes, though so far apparently without any decided success. According to the Germ. Pat. 116092 and 142166 water (with or without the addition of salts) is allowed to drop on to materials such as wax, resins, asphalt, tar or pitch — heated to above 100°C — so that the M. P. and viscosity of the substances are raised considerably. These materials are then, alone or mixed, stirred with caoutchouc and oils, the temperature being gradually raised. They are finally well kneaded in heated kneading machines.

According to the Russian Priv. 6596 (1902) an insulating material for cables &c., intended to replace guttapercha, is obtained by boiling 45 parts asphalt, adding while stirring 40 parts colophony until a thickish substance results. Then 10 parts turpentine and 5 parts linseed oil are added and the boiling continued until the required viscosity is obtained.

The Germ. Pat. 146857 prescribes as follows: Caoutchouc is dissolved in turpentine oil, shellac or asphalt is added, and the whole heated until it becomes uniform. When taken off the fire rice flour, aqueous agar-agar solution and umber are added and stirring continued until solidification occurs; further treatment is carried out between rollers. A substitute for guttapercha is thus obtained which may be vulcanized and still retains the property of becoming plastic when warmed.

Lately the German Telegraphs Department has been trying a cable in which the insulating guttapercha is replaced by "GUTTA-GENTZSCH". This is an artificial guttapercha consisting of pure rubber and a special kind of palm wax. GUTTA-GENTZSCH is said to prove reliable and to be almost as good an insulator as natural guttapercha, while the price of the experimental cable is 35 % less than those insulated with natural guttapercha. See BALATA.

TEST. Crude and purified guttapercha are generally examined in the same manner as caoutchouc. This applies especially to the organic constituents known as guttapercha resins. These are separated and determined like the caoutchouc resins, i. e. by extraction with a medium that does not dissolve guttapercha (e. g. boiling alcohol or acetone, cold ether or petroleum ether) and determining the loss of weight. Besides resins crude guttapercha contains impurities in the form of water and dirt. The water is determined by moderate heating in drying ovens or by leaving for some time in vacuum dessiccators. The dirt is determined by dissolving the guttapercha in carbon bisulphide or chloroform. The insoluble matter is filtered off, washed and weighed.

Care must be taken to use a proper amount of the specimen (at least 100 to 200 g crude guttapercha should be taken).

The purified guttapercha contains but little water and no dirt.

The test is practically the same as is used for the crude guttapercha: The specimen is rolled out into a thin leaf and the small amount of H_2O contained determined by heating in a dry air current. The resins are determined by extraction with one of the solvents mentioned above. After the solvent is distilled off the resins can be weighed, or the amount may be determined indirectly by weighing the guttapercha remaining after the extraction. The guttapercha is then dissolved in CS_2 or in CHCl_3 , filtered and dried *in vacuo*.

The pure guttapercha thus obtained may be pressed into plates in order to determine the strength, elasticity, and electric properties.

Guttapercha:

C. Erdmann, Leipzig-Lindenau.

Gypsum (PLASTER OF PARIS). Gypsum is hydrated calcium sulphate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. Most of the water of crystallization is removed by heating to 110 – 120° , the residue being lost only at 170° . Gypsum which is partially dehydrated takes up water very readily afterwards setting hard. This valuable property is, however, lost if the heating is carried so far that less than 3 % water is left. In this case the gypsum is said to be "dead burnt".

Various methods of burning are adopted, but in all cases the heating must be regular, particularly if the pieces are large, otherwise a mixture of overburnt and underburnt plaster is obtained.

On a small scale the powdered gypsum is heated in iron pans until drops of water no longer condense on a metal plate held over the powder. During the heating process it must be thoroughly stirred.

When dealing with large quantities furnaces differing widely in construction, are employed. If a pure product is desired care must be taken that the gypsum does not come into direct contact with the flame, otherwise calcium sulphide is formed by reduction of the sulphate. For this purpose an oven similar to that used by the baker is employed. It is indirectly heated to the required temperature either by producer gas or by a wood-fire. In the latter case the ash &c. are removed and the gypsum introduced. More modern ovens are made in the form of drums, cylinders or retorts.

Since burnt gypsum is more easily powdered than the natural product, large pieces are usually burnt. Or in some cases, the gypsum is partially burnt, then powdered and the powder again heated.

The different kinds of plaster are obtained by varying the process of burning. That for building purposes is obtained by heating the mineral to red-heat (500°). After this it takes up water very slowly and sets in the course of a few weeks to a very hard transparent mass.

Plaster may be obtained (Germ. Pat. 151462) by heating gypsum with water or salt solution above 100° . Anhydrous crystals separate which after removal from the liquid are dried at about 80° . The product has good cementing qualities and sets quickly. The method may be used for working up old plaster casts and the fine powdered CaSO_4 obtained as by-products.

Gypsum suitable for weighting paper &c. can be obtained (Germ. Pat. 168991) by heating it with water and stirring vigorously. The mixture of finely divided and extremely white crystals and water is allowed to cool while being constantly stirred. The crystals (needles) so formed are filtered off, dried and ground.

Plaster of Paris may be obtained from the ground mineral which is purified by levigating. The paste is allowed to settle into moulds, the mass dried and subsequently burnt (Austrian Pat. 28733, 1907).

To protect plaster casts they are treated with wax or paraffin solutions or with stearic acid. Another method is to treat them with solutions of fluo-silicates or water glass.

VON DECHAND's method of treating with potassium borate and barium hydroxide, and that due to RATHGEN and BORRMANN in which celluloid is employed, are also of importance.

H

Haeman. Under this name is sold a peptone preparation which contains iron sulphocyanide. It is said to be used in cases of chlorosis and similar diseases.

Haematogen. A nutritive substance obtained from defibrinated ox-blood by the addition of glycerine and wine. Prescribed in anaemia.

Haematopan. A haemoglobin preparation obtained from defibrinated blood.

Haematoxylin see "LOGWOOD".

Haemogallol. It is prepared by the action of pyrogallol on defibrinated blood solution.

It is a brownish red powder, sparingly soluble in H_2O . Prescribed as a blood preparation in cases of chlorosis.

Haemol. Obtained by the reducing action of zinc dust on defibrinated blood.

A grey powder, not easily soluble in H_2O , prescribed in chlorosis.

Hamburg blue see "IRON COLOURS".

Hardened glass. This is a kind of glass which resists mechanical influences better than the usual kinds. This property is acquired not by a special receipt for the glass mixture but by rapid cooling of the glass articles. The surface solidifies before the interior, producing strains on which the hardness and elasticity of hardened glass depend.

The hot pieces of glass used to be dipped into warm oil. More efficient is SIEMENS' pressure method:— The softened glass sheets are pressed between cast iron plates and so cooled rapidly. These sheets of hardened glass are used for roofing of buildings, conservatories, &c., frequently with internal wire netting (wire glass), insuring a still higher degree of durability and resistance.

A special kind of hardened glass is COMPOUND GLASS invented by SCHOTT in Jena. It is obtained by combining 2 or better 3 layers of glass of different dimensions. These compound glasses are used for watergauges on boilers, for lamp chimneys (especially for incandescent lighting) and for chemical apparatus (dishes, bottles, &c.). When strongly heated they can be splashed with cold water without breaking.

While SIEMENS' pressed glass and SCHOTT's compound glass may claim considerable importance the original hardened glass cooled with oil or resin has not been used as much as was anticipated on account of certain important disadvantages which it possesses. It is in a state of great strain so that the slightest disturbance causes it to fly to pieces or to powder.

Hardened rubber (EBONITE), see "GUTTAFERCHA" and "CAOUTCHOUC".

Hardening agents. Mixtures which are used partly for converting wrought iron into steel and partly for hardening steel. For the former purpose a mixture of 88 parts of sodium chloride, 9 parts of potassium cyanide, 1 part of potassium bichromate, 1 part salpetre and 1 part of glass is used. For hardening steel a mixture of 24 parts of wood charcoal, 4 parts of horn-filings, 7 parts of glue, 10 parts of salpetre and 55 parts sodium chloride is employed. There is however a large number of such mixtures. Besides the above mentioned substances

the following are often added:— prussiate of potash, sal-ammoniac, chalk, colophony, rye meal, clay, gum arabic, &c.

Hardness. The scale of hardness is as follows:

1. Talc.
2. Gypsum.
3. Calcspars.
4. Fluorspar.
5. Apatite.
6. Orthoclase.
7. Quartz.
8. Topaz.
9. Corundum.
10. Diamond.

Substance	Hardness	Substance	Hardness	Substance	Hardness
Adularia	6	Clay 0°	0.3	Magnesia	4
Agate	7	Copper	2.5—3	Magnetite	4—5
Alabaster	1.7	Copper sulphate ..	2.5	Magnetic iron ore ..	6
Albite	6—6.5	Corundum	9	Marble	3—4
Alum	2—2.5	Diamond	10	Meerschaum	2—3
Amber	2—2.5	Dolomite	3.5—4	Mica	2.8
Ammoniumbi- carbonate	1.5	Epsom salts	2.3	Oligoclase	6
Andalusite	7—7.5	Felspar	6	Opal	5.5—6.5
Anorthite	6	Flint	7	Orthoclase	6
Anthracite	2.2	Galena	2.5	Palladium	4.8
Antimony	3.3	Garnet	7	Platinum	4.3
Antimony glance ..	2	Glauber's salts ..	1.7	Platinum-iridium ..	6.5
Apatite	5	Gypsum	1.6—2	Quartz	7—8.5
Arragonite	3.5	Gypsum (spar) ..	2	Rock salt	2.5
Arsenic	3.5	Gold	2.5—3	Rutile	6—6.5
Asbestos	5	Graphite	0.5—1	Saltpetre	2
Augite	6	Heavy spar	2.5—3.5	Serpentine	3—4
Beryl	7.8	Hornblende	5.5	Silver	2.5—3
Black coal	2—2.5	Ice	1.5	Silver chloride	1.3
Bismuth	2.5	Iridium	6	Sulphur	1.5—2.
Boron	9—10	Iron	4.5	Talc	1
Calamine	5	Iron glance	6	Tinstone	6—7
Calcium fluoride ..	4	Iron pyrites	6.3	Topaz	8
Carborundum	9.5	Iron vitriol	2	Tourmaline	7.3
Calcspars	3	Kaolin	1	Wax 0°	0.2
		Labradorite	6	Zircon	7.5

Heat conductivity. The following coefficients denote the amount of heat passing through a surface 1 mm thick and 1 sq. mm in area per second. The two surfaces have a difference of temperature of 1°.

The values are given in milligramme calories.

Heating worms.

Heating worms in copper:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Heating apparatus.

Heating apparatus:

Gustav Barthel, Dresden-A. 19 (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

SOLIDS.

Brass	30.20	Ice	0.23
Brass Red.	24.60	Iron, wrought	20.70
Caoutchouc	0.009	Lead	7.19
Copper	98.23	Magnesium	37.60
Cork	0.071	Mercury	1.47
Cotton	0.004	Quartz sand	0.013
Felt	0.009	Slate	0.081
Fir (axial)	0.030	Silver	109.60
Fir (radial)	0.009	Steel, Bessemer	9.64
German silver	10.94	„ Cast	14.18
Glass	0.13	Tin	14.46
Hardrubber	0.026	Zinc	30.71

LIQUIDS.

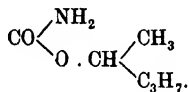
Alcohol	0.150	Ether	0.040
Benzene	0.033	Glycerine	0.075
Copper sulphate solution	0.118	Olive oil	0.039
		Water	0.155

GASES.

Air	0.00492	Hydrogen	0.03324
Ammonia	0.00458	Oxygen	0.00563
Carbon dioxide	0.00305	Nitrogen	0.00524

Heavy spar (BARYTES, BARIUM SULPHATE). BaSO_4 . It is found widely distributed in nature in a rough crystalline form. It is hard and brittle, transparent to translucent, white or owing to impurities yellow, reddish or grey; S. G. 4.3—4.6. Further details see under "BARIUM COLOURS".

Hedonal Methylpropylcarbinolurethane (i. e. the ester of methylpropylcarbinolcarbonic acid)



The ester of this alcohol is obtained by the action of chlorcarbonic acid on secondary amyl-alcohol (methylpropylcarbinol) $\text{CH}_3 \cdot \text{C}_3\text{H}_7 \cdot \text{CH}(\text{OH})$. It is converted into hedonal by treatment with ammonia.

Colourless crystals M. P. 76° . Sparingly soluble in cold, more easily in hot water.

Used as a hypnotic in cases of neurasthenia and hysteria. Dose 1.5 to 2 g either in the solid or in alcoholic solution.

Hectographs. A good receipt is: 160 g gelatine, 250 g water, 600 g glycerine and 250 g sugar.

HECTOGRAPHIC SHEETS are now largely used. They are made as follows:—4 parts light glue are put into a mixture of 5 parts H_2O and 3 parts NH_3 for 6—8 hours until the glue has become soft. Then the whole is melted in the water bath; 3 parts powdered sugar are added with 8 parts glycerine and heated to boiling with continuous stirring.

While hot the substance is smeared over absorbent paper until the latter is thoroughly saturated and has a slight excess on the surface. After 2—3 days

the sheets are ready for use; when kept dry and free from dust they last almost indefinitely. Immediately before use they are moistened with a wet sponge. After use they are left for 2 days when they are ready to be used again, as the ink has meanwhile sunk inside. The same substance can be used for casting thicker cakes.

There are many receipts for hectographic inks; the following two may be mentioned as efficient: a) 1 part methyl violet, 1 part alcohol, 8 parts H_2O ; b) 5 parts methyl violet, 5 parts alcohol, 5 parts gum, 35 parts H_2O .

Helmitol. The hexa-methylene-tetramine compound (i.e. a urotropine compound) of methylene citric acid anhydride. $C_7H_8O_7 \cdot (CH_2)_6N_4$.

It is a white crystalline powder, with an acid reaction, easily soluble in H_2O , scarcely soluble in alcohol and ether, melting with decomposition at 165 to $175^\circ C$.

Prescribed as an internal antiseptic in cases of diseases of the bladder, as a substitute for urotropine (see **HEXA-METHYLENE-TETRAMINE**), to which it is said to be superior in many ways. Single dose 1 g, three to four times daily.

Helwig's Blood-solvent. Solution of 1 part KI in 4 parts H_2O . It dissolves dried blood spots without changing the colouring matters of the blood.

Hemp. Bast fibres of the hemp plant *Cannabis sativa* which are prepared in a manner similar to that used for flax. The length of the hemp fibre is from one to two metres, the width 0.010 — 0.025 mm. The value depends upon the length, fineness and strength of the fibre. It is used in making ropes and sail cloth.

Hercules powder see "DYNAMITE".

Heroin = di-acetylmorphine. Obtained by heating morphine with acetyl-chloride.

White crystalline powder, which is odourless and has a bitter taste. M. P. $173^\circ C$, nearly insoluble in H_2O ; readily soluble in acids.

It is used medicinally as a substitute for morphine and codeine for pulmonary catarrh. Dose:— 0.005 — 0.02 g several times a day in powders (with sugar). Aqueous solutions can only be obtained by adding acetic acid. Maximum dose 0.06 g or 0.2 g daily.

Hetocresol. The m-cresolester of cinnamic acid. Used in the surgical treatment of tuberculosis (subcutaneous injection).

Hetol. This is the trade name for synthetic sodium cinnamate.

White crystalline powder M. P. 133 — 134° . Prescribed for pulmonary tuberculosis. Single Dose 0.0005 — 0.001 g (subcutaneously).

Hetraline = di-oxy-benzene-hexa-methylenetetramine. $C_8H_{12}N_4 \cdot C_6H_4O_2$, resulting by combining hexa-methylene-tetramine (q. v.) with resorcin.

Colourless needles, unchanged in the air, with a sweet taste and creosote-like smell; soluble in 14 parts H_2O , less readily in alcohol and $CHCl_3$, very sparingly in ether; when heated to 150 — 160° it begins to decompose.

It is prescribed as an urinary antiseptic in the same way as hexa-methylene-tetramine.

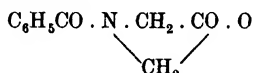
Hexa-methylene-tetramine (urotropine, formine). $N_4(CH_2)_6$. A condensation product of formaldehyde and ammonia; obtained by passing dry NH_3 over

heated paraformaldehyde. In order to purify it it is crystallized from boiling alcohol.

Colourless and odourless crystals, with a sweetish taste and a bitter after taste, easily soluble in H_2O , less readily in alcohol, very sparingly in ether.

It is used as a solvent for uric acid in doses of 1—2 g daily (aqueous solution) and in doses of 4—6 g daily as a diuretic.

Hippol. Methylenehippuric acid



Obtained by the action of polymerized formaldehyde on a solution of hippuric acid in H_2SO_4 (conc.), (Germ. Pat. 148669).

Odourless, tasteless, prismatic crystals M. P. 151° . Used as a non-poisonous antiseptic in inflammation of the bladder.

Hirudine. The substance of the leech which prevents blood from clotting, obtained according to the Germ. Pat. 136103.

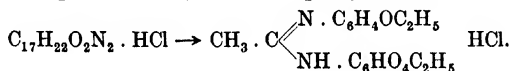
It is used medicinally. 1 mg hirudine is sufficient to keep 7.5 ccm blood liquid without changing the property of the blood.

Histosan (triguaicolalbuminate). Prepared according to Germ. Pat. 162656.

A pale brown powder with a faint aromatic smell and taste, insoluble in alcohol, ether and acids, soluble in alkalis.

Used in the early stages of tuberculosis and infectious diseases of the respiratory organs, in the form of a powder, in tablets or as a syrup.

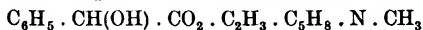
Holocaine = para-di-ethoxy-ethenyl-di-phenyl-amidine hydrochloride



Phosphorus oxychloride is allowed to act on a mixture of para-phenetidine sulphate and phenacetin, when holocaine sulphate is formed. The base is set free by caustic soda solution and purified by means of alcohol. The free base is dissolved in hot hydrochloric acid, from which the hydrochloride separates in crystals on cooling.

The hydrochloride dissolves sparingly (2%) in cold, less readily in hot H_2O . It is used by oculists, as a local anaesthetic as a substitute for cocaine: a 1% aqueous solution is generally used.

Homatropine. The tropine ester of mandelic acid



prepared synthetically from mandelic acid and tropine. An alkaloid which as regards its property of dilating the pupils has certain advantages over atropine and is consequently frequently preferred; it is used in the form of salts. Maximum dose 0.001 g or 0.003 g daily.

Honey. Obtained by allowing it to flow out of the comb or by pressing it out. It is a clear viscid liquid, varying from pale yellow to brownish-yellow in colour. On standing in the cold it becomes almost solid owing to the crystallization of the grape-sugar present. S. G. 1.38 to 1.40; in the solid state S. G. 1.42—1.44; (α)_D = -0.3° to $+0.4^\circ$. If strongly dextro-rotatory the presence of starch sugar (i. e. impure glucose) may be suspected.

Genuine honey contains 22.7—44.7 % glucose, 32.2—46.9 % fructose, 0—8.2 % cane sugar, 16.3—24.9 % water and 1.3—8.8 % of non-saccharine substances.

An artificial honey is now made from cane — or beet — sugar which is similar to the natural product not only in appearance and taste but also in its chemical and physical properties. It is, however, not a purely artificial product, but a mixture of honey and invert sugar. Without the former the peculiar taste cannot be obtained.

Hops. The dried ripe fruit of the hop plant *Humulus lupulus*, used as the bitter principle in brewing. The action is due to the hop resin and the bitter substance of the hop. In order to preserve the hops they must be first deprived of a portion of the water they contain. This is carried out in a species of kiln. They may be preserved unchanged for a long time by treatment with gaseous SO_2 . Still more largely used is a method of preservation which consists in pressing the hops into metal chests, sealing up the latter and pumping out all air through a hole in the cover.

Extracts of hops are also sold. They are obtained by boiling the hops with water in apparatus of special construction.

Horn, artificial. According to THOMSON (Chem.-Ztg. 1903, Repert. 103) an artificial horn called KORNITE is obtained from horn scraps in the following manner: The horn residues are washed, dried and finely powdered. The powder is dyed black and pressed into plates by hydraulic pressure. Kornite is not as elastic as natural horn though it can be used for many purposes, especially in electrotechnical works as a substitute for ebonite.

According to the Germ. Pat. 184915 plastic substances similar to horn may be prepared from keratine — containing materials (horn scraps, hair, &c.) by first treating them with dilute mineral acids at a temperature not exceeding 70° , and then with alkaline lyes until they swell up or dissolve completely. The mass is then pressed into moulds.

According to the Germ. Pat. 127942 horn-like substance can be prepared from caseine in the following way: Caseine solutions or dried soluble caseine is rendered insoluble by salts or acids; the product is dried by evaporation or by pressure until it becomes hard and transparent, and is finally treated with formaldehyde (see "GALALITH").

According to the Germ. Pat. 153228 dried caseine is dissolved in dilute caustic soda solution and heated with the addition of sulphur. (At least the same amount of S as the alkali used must be added.) The resulting clear liquid is thickened down to the consistency of a syrup, lead hydroxide, zinc hydroxide, or water glass being added to harden the final product; for filling and to increase the drying property, wood meal, cork, sand, emery, &c. may be used. The substance is cast into plates and dried. Variations are described in Germ. Pat. 163818 and the French Pat. 367407.

The raw material for the manufacture of horn-like substances (Germ. Pat. 145106, 151918, 152111) is acetyl cellulose, which is treated with mono- or poly-hydric phenols or their substituted derivatives, or finally with chloralhydrate. Acetone has also proved a good solvent. The mixtures are warmed for some time to $40\text{--}600^\circ$ and allowed to cool and solidify in air.

In Amer. Pat. 774713 and 774714 cellulose acetate is also used as the raw material in the manufacture of horn substitutes. It is heated with thymol and CHCl_3 or with a phenol alone under pressure. Instead of thymol castor oil may be employed.

Horn meal see „MANURES, ARTIFICIAL“.

Huiles antiques see „PERFUMERY“.

Hydraulic mortar see „CEMENTS“.

Hydrastine. $C_{21}H_{21}NO_6$. Alkaloid found in the root of the North American *Hydrastis canadensis* (Ranunculaceae). The constitution is similar to that of narcotine.

Hydrastine is used medically for the same purposes as ergot.

Hydrazine. $H_2N.NH_2$. Now prepared in the form of its sulphate from ammonia and hypochlorite. The ammonia is first converted into monochloramine $NH_3 + NaOCl = NH_2Cl + NaOH$. Into this compound an amido group replacing the Cl is then introduced $NH_2Cl + NH_3 = N_2H_4 + HCl$. The mixture of hydrazine and NaCl is then evaporated with H_2SO_4 when the sparingly soluble sulphate separates.

Hydrazo compounds see “AZO COMPOUNDS”.

Hydriodic acid. HI. Can be obtained by distilling KI with H_3PO_4 . It is, however, more easily prepared by means of phosphorus. Two reactions take place simultaneously, firstly the formation of phosphorus tri-iodide PI_3 , and secondly the decomposition of PI_3 by water. Phosphorous acid and HI are formed $PI_3 + 3 H_2O = 3 HI + H_3PO_3$. One part amorphous phosphorus is mixed with 15 parts H_2O . 20 parts powdered I are gradually added with cooling and the whole carefully heated; the escaping HI is passed into water. Another method is to dissolve yellow phosphorus in carbon bisulphide, add iodine (which forms PI_3) and to distil off the CS_2 ; when water is allowed to drop on to the solid residue after cooling HI is evolved.

Colourless gas, strongly fuming in moist air, easily soluble in H_2O . A saturated aqueous hydriodic acid has a S. G. 1.700 and contains about 52 % HI.

Hydrocellulose see “OXYCELLULOSE”.

Hydrochloric acid. HCl. This acid is obtained as a by-product in the manufacture of salt cake (q. v.) by decomposing NaCl with H_2SO_4 according to the equation: $2 NaCl + H_2SO_4 = 2 HCl + Na_2SO_4$. HCl-gas on being absorbed with H_2O gives the common hydrochloric or muriatic acid of commerce. The condensation must be so carried out that the HCl-gas may have every chance of being absorbed by the water; and since if fairly strong acid is required, the quantity of water cannot be indefinitely increased, care must be taken that the H_2O is repeatedly brought into contact with HCl, and that the strongest acids meet the gases richest in HCl, and on the other hand that the pure H_2O meets the gases which are already almost free from HCl. Before the HCl is condensed provision must be made for the strong cooling of the gas. The method of condensation varies according to the quantity of air mixed with the HCl. The HCl from the pans and that from the hearth of the furnace are led off separately, because the HCl from the pan is purer and more concentrated, while the impure acid from the hearth does not come into the market, but is worked up for the use of the factory. The two batteries belonging to an apparatus for condensation consist of a washing tower of acid proof sandstone tiles, which are kept moist but not cool, so that scarcely any HCl but the greater part of the H_2SO_4 mixed with it is retained. From this starting point the vapour passes through a great number of earthenware vessels on every side, and thus reaches a condensation tower (coke tower, plate tower or ball tower) where the gas entering from below is freed from the last traces of HCl by the H_2O which drips from above. See also REACTION TOWERS and NITRIC ACID. From the towers the weak acids present, which are about

8° B_é, flow through the different chambers, always in a direction opposite to that of the gas, so that at the end of the series (that is where the gas enters) the acid runs out, having a strength of 20—22° B_é.

The HCl obtained is treated with H₂S or BaS to free it from As. The BaS also at the same time frees it from the H₂SO₄, which otherwise would have to be removed with BaCl₂. Crude HCl is usually of a reddish colour because of the presence of finely divided selenium, which is removed together with the As.

To obtain perfectly pure HCl, the crude acid after being freed from As is distilled from glass retorts, or H₂SO₄ is allowed to run into it and the hydrochloric acid given off is absorbed in water.

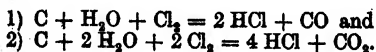
The method of OEHLER (Germ. Pat. 136998) seems to be practicable. Powdered anhydrous (fused) NaHSO₄ is added to the crude acid with which it is shaken and at the same time conc. H₂SO₄ is allowed to run in. Dry HCl is given off and fresh quantities of NaHSO₄ are formed by the addition of NaCl and H₂SO₄.

The Germ. Pat. 121886 and 123861 have recently attained importance in the manufacture of pure hydrochloric acid. According to the former the process is as follows:—The pure HCl is made in lead vessels by allowing the crude hydrochloric acid (free from As) to flow into a solution of hot H₂SO₄. Pure hydrochloric acid of the same degree of concentration as that first used distills over. The sulphuric acid bath is heated by a steam coil. The second patent differs from the first only in one point. The crude acid instead of flowing into H₂SO₄ flows into a bath of boiling MgCl₂ solution which is kept at a constant temperature of 118—120°. In this case too the hydrochloric acid distilling over has exactly the same strength as the crude acid had and is further free from H₂SO₄ and Fe. The H₂SO₄ present in the crude HCl liberates HCl from the MgCl₂, with formation of MgSO₄, which by suitable means may be recovered. HCl containing As may be purified by passing the gases through warm solutions of vanadous salts. The As is precipitated in the metallic form and the vanadous compound converted into a higher state of oxidation (Germ. Pat. 164355).

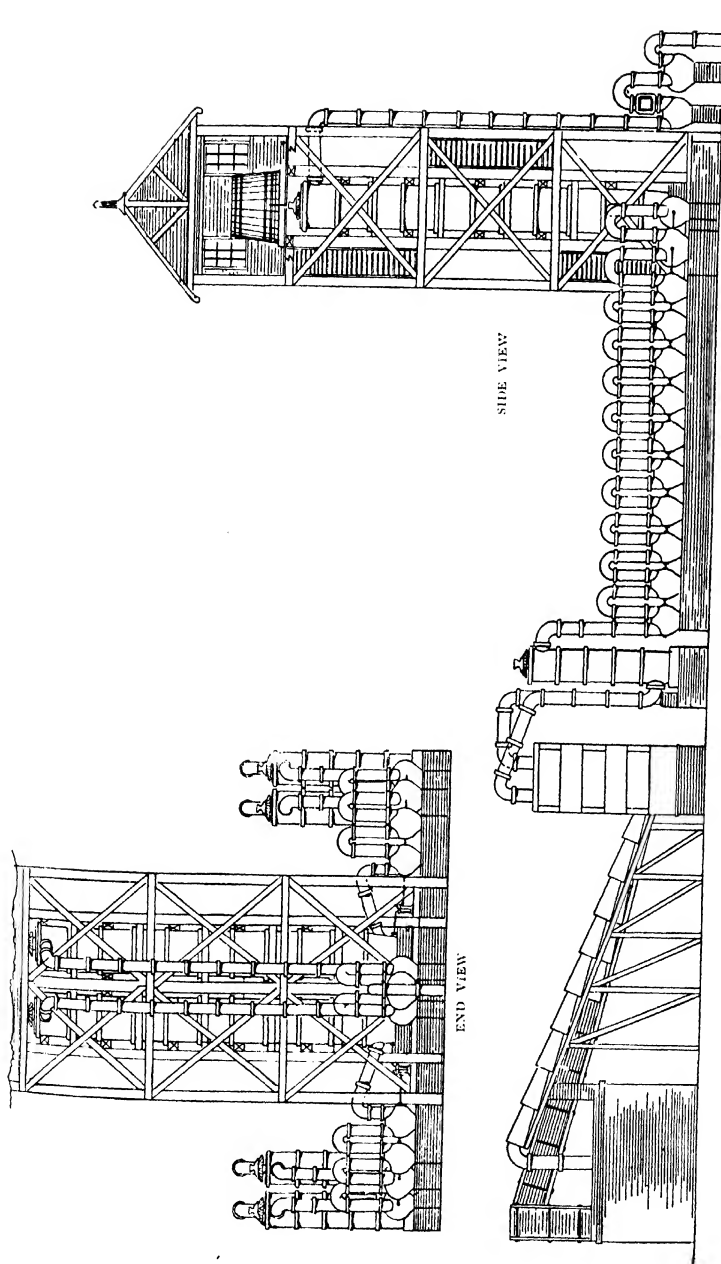
According to Germ. Pat. 179513 and 179514 As may be removed by passing the impure gases through scrubber towers containing mineral oils. The latter are said to retain the As and other impurities.

An attempt has been made to obtain HCl from the magnesium mother liquors left in the preparation of potassium salts from the Stassfurt deposits. The strongest concentrated solution of MgCl₂ is first evaporated and then heated in retorts, into which steam is simultaneously conducted. The action corresponds to the equation: $MgCl_2 + H_2O = MgO + 2HCl$. Hydrochloric acid is prepared by this process in some works, but as yet the acid obtained by the LEBLANC process has been able to hold its own.

A further proposition has been made to obtain this acid from electrolytically prepared chlorine. The method of procedure is to conduct Cl₂ mixed with steam over gently heated coke when reactions corresponding to the following equations take place:—



This conversion of Cl₂ first obtained from the decomposition of chlorides, into HCl implies however, taken in the purely thermo-chemical sense, a backward step so that such a process must at once give rise to economical doubts. In spite of this, new methods all of the same nature are being continually put forward. The financial success of these methods can only be assured if the Cl be regarded as a secondary product in the electrolytic process for the manufacture of chlorine (see CHLORINE ELECTROLYTICAL PROCESS).



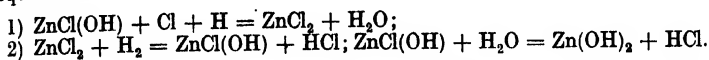
SIDE VIEW

END VIEW

HYDROCHLORIC ACID APPARATUS

(Doulton & Co., Ltd., Lambeth)

Other contact substances besides coke have been used in these methods. In these a mixture of Cl and H is used. According to the Germ. Pat. 166598 it is of advantage to conduct the gas mixtures over metallic chlorides instead of over contact substances. The metallic chlorides used are those of Al, Zn or Sn. The chloride in question is decomposed by heat in the presence of H_2O , into basic chloride, hydroxide and HCl. These basic bodies can then again be used for absorbing Cl and H. The reaction corresponds to the following equations:—



As these reactions take place in aqueous solutions, the mixture of Cl and H, as formed in the electrolysis of alkaline chlorides, can be conducted after saturation with hot steam over porous substances which have been soaked in solutions of metallic chlorides, or the gases can be passed through solutions of the chlorides. The most favourable temperature for the reaction is about 100° . The process is probably a good one for the preparation of HCl and HBr.

The Germ. Pat. 158086 deals with the preparation of HCl with simultaneous recovery of the products of dry distillation of wood. The Cl is allowed to act upon wood or similar organic substances at a temperature of $150-300^\circ$. It is asserted that charcoal, alcohol, acetic acid, hydrochloric acid and tar are thus obtained. This process will certainly fail to become of any importance.

Finally those methods must be mentioned which aim at obtaining HCl by bringing chlorine and SO_2 into contact with each other. Among these methods are those of the French Pat. 324859, the English Pat. 14342 (1903) and the Germ. Pat. 157043 and 157044. The last named patent is as follows:—Cl and pyrites gases are introduced through the bottom of a reaction tower which is filled with stones, while from above only so much H_2O is allowed to flow as suffices for the formation of gaseous HCl and conc. H_2SO_4 . Further details will be found in the papers of this patent. The whole process for obtaining HCl and H_2SO_4 simultaneously seems too cumbersome, too expensive and too liable to the occurrence of undesirable secondary reactions.

Dry hydrogen chloride is a colourless gas (S. G. 1.2596) which fumes strongly in the air. It can be condensed to a liquid by cooling under high pressure. An aqueous solution of HCl is colourless and fumes in the air. On being heated it loses HCl and H_2O and until the specific gravity sinks to 1.101. After this the concentration and B. P. remain constant (B. P. 110°).

The following table shows the S. G. of hydrochloric acids of various degrees of concentration.

HCl is used for the manufacture of Cl, KClO_3 , bleaching powder and different chlorides, of CO_2 , superphosphate, phosphorus, bone glue and so on. It is also used in metallurgy and in dyeing, further it is employed in many other ways.

TEST. The strength is usually determined by means of hydrometers, using the above tables of LUNGE and MARCHEWSKI. For exact measurements 10 ccm of the acid, of known S. G., are diluted with distilled H_2O to 200 ccm. 10 ccm are then measured off and exactly neutralized or made faintly alkaline with soda and the Cl then titrated with solution $\frac{N}{10}$. AgNO_3 solution

with K_2CrO_4 as indicator. To determine H_2SO_4 the HCl is not quite neutralized with Na_2CO_3 and is then precipitated in the usual way with BaCl_2 . Fe is titrated with KMnO_4 after reducing with Zn and adding manganese sulphate. SO_2 is oxidized to H_2SO_4 and this is determined with BaCl_2 . From the difference between the total H_2SO_4 and the original amount the SO_2 is calculated. KRAUCH's test for As is as follows:— 10 g HCl are diluted with

LUNGE and MARCHLEWSKI's Tables.

S. G. $\frac{16^{\circ}}{4^{\circ}}$ in vacuo	Degrees		100 parts contain of chemically pure acid %						1 litre contains kg					
	Beaumé	Twaddell							HCl	acid of				
			HCl	18° acid	19° acid	20° acid	21° acid	22° acid		18° Bé	19° Bé	20° Bé	21° Bé	22° Bé
1.005	0.7	1	1.15	4.08	3.84	3.58	3.42	3.25	0.012	0.041	0.039	0.036	0.034	0.033
1.010	1.4	2	2.14	7.60	7.14	6.66	6.36	6.04	0.022	0.077	0.072	0.067	0.064	0.061
1.015	2.1	3	3.12	11.08	10.41	9.71	9.27	8.81	0.032	0.113	0.106	0.099	0.094	0.089
1.020	2.7	4	4.13	14.67	13.79	12.86	12.27	11.67	0.042	0.150	0.141	0.131	0.125	0.119
1.025	3.4	5	5.15	18.30	17.19	16.04	15.30	14.55	0.053	0.188	0.176	0.164	0.157	0.149
1.030	4.1	6	6.15	21.85	20.53	19.16	18.27	17.38	0.064	0.225	0.212	0.197	0.188	0.179
1.035	4.7	7	7.15	25.40	23.78	22.27	21.25	20.20	0.074	0.263	0.247	0.231	0.220	0.209
1.040	5.4	8	8.16	28.99	27.24	25.42	24.25	23.06	0.085	0.302	0.283	0.264	0.252	0.240
1.045	6.0	9	9.16	32.55	30.58	28.53	27.22	25.88	0.096	0.340	0.320	0.298	0.284	0.270
1.050	6.7	10	10.17	36.14	33.95	31.68	30.22	28.74	0.107	0.380	0.357	0.333	0.317	0.302
1.055	7.4	11	11.18	39.73	37.33	34.82	33.22	31.59	0.118	0.419	0.394	0.367	0.351	0.333
1.060	8.0	12	12.19	43.32	40.70	37.97	36.23	34.44	0.129	0.459	0.431	0.403	0.384	0.365
1.065	8.7	13	13.19	46.87	44.04	41.09	39.20	37.27	0.141	0.499	0.469	0.438	0.418	0.397
1.070	9.4	14	14.17	50.35	47.31	44.14	42.11	40.04	0.152	0.539	0.506	0.472	0.451	0.428
1.075	10.0	15	15.16	53.87	50.62	47.22	45.05	42.84	0.163	0.579	0.544	0.508	0.484	0.460
1.080	10.6	16	16.15	57.39	53.92	50.31	47.99	45.63	0.174	0.620	0.582	0.543	0.518	0.493
1.085	11.2	17	17.13	60.87	57.19	53.36	50.90	48.40	0.186	0.660	0.621	0.579	0.552	0.523
1.090	11.9	18	18.11	64.35	60.47	56.41	53.82	51.17	0.197	0.701	0.659	0.615	0.587	0.558
1.095	12.4	19	19.06	67.73	63.64	59.37	56.64	53.86	0.209	0.742	0.697	0.650	0.620	0.590
1.100	13.0	20	20.01	71.11	66.81	62.33	59.46	56.54	0.220	0.782	0.735	0.686	0.654	0.622
1.105	13.6	21	20.97	74.52	70.01	65.32	62.32	59.26	0.232	0.823	0.774	0.722	0.689	0.655
1.110	14.2	22	21.92	77.89	73.19	68.28	65.14	61.94	0.243	0.865	0.812	0.758	0.723	0.687
1.115	14.9	23	22.86	81.23	76.32	71.21	67.93	64.60	0.255	0.906	0.851	0.794	0.757	0.719
1.120	15.4	24	22.82	84.64	79.53	74.20	70.79	67.31	0.267	0.948	0.891	0.831	0.793	0.754
1.125	16.0	25	24.78	88.06	82.74	77.19	73.64	70.02	0.278	0.991	0.931	0.868	0.828	0.788
1.130	16.5	26	25.75	91.50	85.97	80.21	76.52	72.76	0.291	1.034	0.972	0.906	0.865	0.822
1.135	17.1	27	26.70	94.88	89.15	83.18	79.34	75.45	0.303	1.077	1.011	0.944	0.901	0.856
1.140	17.7	28	27.66	98.29	92.35	86.17	82.20	78.16	0.315	1.121	1.053	0.982	0.937	0.891
1.1425	18.0		28.14	100.00	93.95	87.66	83.62	79.51	0.322	1.143	1.073	1.002	0.955	0.908
1.145	18.3	29	28.61	101.67	95.62	89.13	85.02	80.84	0.328	1.164	1.094	1.021	0.973	0.926
1.150	18.8	30	29.57	105.08	98.73	92.11	87.87	83.55	0.340	1.208	1.135	1.059	1.011	0.961
1.152	19.0		29.95	106.43	100.00	93.30	89.01	84.63	0.345	1.226	1.152	1.075	1.025	0.975
1.155	19.3	31	30.55	108.58	102.00	95.17	90.79	86.32	0.353	1.254	1.178	1.099	1.049	0.997
1.160	19.8	32	31.52	112.01	105.24	98.19	93.67	89.07	0.366	1.299	1.221	1.139	1.087	1.033
1.163	20.0		32.10	114.07	107.17	100.00	95.39	90.70	0.373	1.326	1.246	1.163	1.109	1.054
1.165	20.3	33	32.49	115.46	108.48	101.21	96.55	91.81	0.379	1.345	1.264	1.179	1.125	1.070
1.170	20.9	34	33.46	118.91	111.71	104.24	99.43	94.55	0.392	1.391	1.307	1.220	1.163	1.106
1.171	21.0		33.65	119.58	112.35	104.82	100.00	95.09	0.394	1.400	1.316	1.227	1.171	1.113
1.175	21.4	35	34.42	122.32	114.92	107.22	102.28	97.26	0.404	1.437	1.350	1.260	1.202	1.143
1.180	22.0	36	35.39	125.76	118.19	110.24	105.17	100.00	0.418	1.484	1.394	1.301	1.241	1.180
1.185	22.5	37	36.31	129.03	121.23	113.11	107.90	102.60	0.430	1.529	1.437	1.340	1.279	1.216
1.190	23.0	38	37.23	132.30	124.30	115.98	110.63	105.20	0.443	1.574	1.479	1.380	1.317	1.252
1.185	23.5	39	38.16	135.61	127.41	118.87	113.40	107.83	0.456	1.621	1.523	1.421	1.355	1.289
1.200	24.0	40	39.11	138.98	130.68	121.84	116.22	110.61	0.469	1.667	1.567	1.462	1.395	1.326

10 ccm H_2O in a test tube and carefully covered with 5 ccm of a freshly prepared solution of hydrogen sulphide. After standing for an hour either in a cold or in a warm place, there should be no colouration and no yellow ring between the two layers. The sensitiveness of the test is so great that 0.000005 g As in 1 g HCl (that is $\frac{1}{200}$ mg in the amount taken may be detected). For the quantitative determination of As the $AsCl_3$ present is reduced by passing SO_2 through for some time and precipitating as As_2S_3 with H_2S . The ppt.

is then well washed and dissolved on the filter in NH_4OH . The solution is evaporated in a tared dish. The As_2S_3 is then dried at 100° and weighed. $1 \text{ g } \text{As}_2\text{S}_3 = 0.60975 \text{ g As} = 0.80488 \text{ As}_2\text{O}_3$.

Free Cl can be recognized by the smell; on warming, the diluted acid also colours potassium iodide starch paper blue.

Earthenware-Condensation vessels for hydrochloric acid:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Transport vessels for hydrochloric acid:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Hydrochloric acid plants of Earthenware:

Westdeutsche Steinzeug-Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Hydrogen. H. Atomic weight = 1.008 (O = 16.00). Transparent, colourless, tasteless, odourless gas burning in air with a very hot, non-luminous flame, with formation of H_2O . It is the lightest of all substances;— 1 l H weighs at 0°C (45° latitude) under 760 mm mercury 0.089873 g; S. G. of hydrogen = 0.0695, air = 1. Critical temperature -234°C ; critical pressure 20 atm. Liquid hydrogen boils at -243° under 760 mm mercury. Solid hydrogen has been obtained by DEWAR from the liquid by partial evaporation (at 50 mm pressure) with external cooling by liquid air. Solid hydrogen melts, when the pressure of the vapours reach 55 mm at $16-17^\circ$ absolute; the critical temperature is about $30-32^\circ$ (absolute).

H is prepared by treating Zn or Fe with dilute mineral acids (HCl or H_2SO_4). In the Russian war another method proved to be reliable, viz. that of obtaining H from aluminium and caustic soda solution. Another method is that of MAJERT and RICHTER in which a mixture of calcium hydroxide and zinc is heated to red heat in iron retorts. This method in which the reaction corresponds to the equation $\text{Ca}(\text{OH})_2 + \text{Zn} = \text{H}_2 + \text{CaO} + \text{ZnO}$ has been recommended for filling balloons for military purposes at short notice.

Hydrogen can also be obtained by passing steam over red-hot iron; further, from water-gas (q. v.) practically pure H may be produced by passing it through absorbents which remove CO_2 and CO.

Pure H may be obtained from watergas (Germ. Pat. 174324) by passing the latter, after drying, over heated calcium carbide at 300° . According to the supplement to Germ. Pat. 177703 a previous purification of the watergas may be carried out by physical means in a LINDE liquefying apparatus.

The electrolytic preparation of H by the decomposition of acidified water or solution of caustic soda is becoming important. Many forms of apparatus have been described.

The large amount of hydrogen formed as a by-product in the electrolysis of alkaline chlorides (see "CHLORINE ALKALI PROCESS, ELECTROLYTICAL") is now utilized by several firms, particularly by the Chemische Fabrik Griesheim Elektron. From this factory hydrogen is exported in a pure state under a pressure of 150 atm. Hydrogen is also now obtained from hydrolith which gives off the gas on warming with water. The hydrolith is convenient for transport.

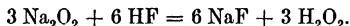
Hydrogen is used in lead soldering (q. v.), welding (q. v.), for filling balloons and as a heating agent. For the latter purpose it should completely replace coal gas (in laboratories) as it is, contrary to all expectations, less explosive than the latter. In consequence of its low specific gravity and high velocity of diffusion it is distributed very rapidly, forming non-explosive mixtures, so that several jets could be left open for hours without danger. The flame is much hotter than that of coal-gas and is therefore well suited for glass-blowing, does not deposit carbon, contains no oxides of sulphur, so that it

does not injure platinum vessels like the flame of coal gas, nor cause errors in analysis by the formation of H_2SO_4 .

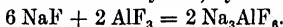
Hydrogen Peroxide. For the preparation of hydrogen peroxide, the hydrate of barium peroxide is first obtained by dissolving finely powdered BaO_2 in dilute HCl until the acid is almost neutralized, filtering, cooling and adding enough baryta water to precipitate SiO_2 and other oxides and to produce a small precipitate of the hydrate of barium peroxide. The solution is again filtered and the hydrate of barium peroxide precipitated with an excess of baryta water. This is washed and kept moist. H_2O_2 is obtained by mixing and stirring the moist product with diluted H_2SO_4 (1 : 5 H_2O) until the acid is almost neutralized. After filtering off the BaSO_4 the last traces of H_2SO_4 in the filtrate are precipitated with baryta water and the solution again filtered.

H_2O_2 is also largely prepared from BaO_2 and H_2SiF_6 .

According to the Germ. Pat. 132090 aqueous H_2O_2 solutions are obtained from sodium peroxide by carefully dissolving the latter at a low temperature in a solution of hydrofluoric acid. The reaction is in accordance with the following equation:—



Aqueous solutions of sodium fluoride and hydrogen peroxide are formed; the former is converted into artificial cryolite, by adding aluminium fluoride:



The cryolite separates out. The H_2O_2 -solution obtained by one of these methods is generally put straight on the market. Concentrated H_2O_2 is only seldom prepared by freezing, drying in vacuum dessicators over sulphuric acid or by evaporating in a current of dry air. Concentrated H_2O_2 is a colourless liquid of a syrupy consistency, of a bitter taste, smelling something like HNO_3 , S. G. 1.499, readily soluble in H_2O and alcohol. Pure H_2O_2 explodes very violently under various conditions, while aqueous solutions will keep and are perfectly harmless. H_2O_2 acts as a strong reducing and also as a strong oxidizing agent. According to STAEDT (Zeitschr. f. angew. Chem. 1902, 642) H_2O_2 can readily be prepared on a large scale in an anhydrous and crystalline form by cooling concentrated 96 % solution with a mixture of ether and CO_2 . If a particle of the solid substance thus obtained is dropped into the 96 % solution cooled to -8°C beautiful column-shaped colourless crystals of chemically pure H_2O_2 are formed. The M. P. of the solid is -2° . Platinum sponge or MnO_2 cause it to decompose with explosive violence. Wool, carbon, magnesium powder, &c. catch fire instantaneously in hydrogen peroxide. Curiously enough reduced iron does not react in this way. The crystalline preparation is said to be transportable without great danger.

According to the Germ. Pat. 152173 which deals with the preparation of highly concentrated chemically pure solutions of H_2O_2 , the crude hydrogen peroxide obtained from Na_2O_2 and H_2SO_4 is distilled without the previous removal of the dissolved Na_2SO_4 . The owner of the Patent (E. MERCK) protected the name PERHYDROL for 100 % hydrogen peroxide, i. e. a preparation containing 30 % H_2O_2 by weight, which gave 100 vol. active oxygen on decomposition. Perhydrol is used as an external antiseptic, and is prepared by treating the calculated amount of Na_2O_2 with 20 % H_2SO_4 , the mixture being cooled.

A good method of preparing hydrogen-peroxide of a high degree of purity starts from sodium perborate (see "SODIUM COMPOUNDS AND PERBORATES"). When 170 g sodium perborate and 60 g citric acid are dissolved in 1 l H_2O a neutral 10 vol. solution is formed, which behaves like H_2O_2 and can be used for medicinal purposes.

Even better is the process of obtaining H_2O_2 from barium percarbonate (see BARIUM COMPOUNDS). According to Germ. Pat. 179771 CO_2 is allowed to act on BaO_2 in presence of water, and the percarbonate is then decomposed with formation of BaCO_3 and H_2O_2 .

H_2O_2 may also be obtained by treating pure barium percarbonate with H_2O . (Germ. Pat. 179826.)

An electrolytical method for preparing H_2O_2 is protected by the French Pat. 371043. It may be obtained in a solid form by gentle warming, adding glycerine and dissolving gelatine in the mixture (Germ. Pat. 185597).

Hydrogen peroxide is an excellent bleaching agent, used for bleaching fabrics, feathers, ivory, hair, &c.; also as a disinfectant in medicine, for restoring old paintings and drawings and for various other purposes.

Optical Analysis according to Prof. Haber:

Prosp. by Carl Zeiss, Jena (Germany).

Hydrol. Registered name (Germany) for certain oils soluble in water. They are used in metal work and as lubricants and rust-preventers in various parts of hydraulic machines.

Hydrolith. Calcium hydride, CaH_2 , obtaining by heating metallic calcium to 800° in a current of hydrogen.

When pure it is white, but the commercial article occurs as grey lumps. It decomposes when treated with water and develops hydrogen according to the equation $\text{CaH}_2 + 2 \text{H}_2\text{O} = \text{Ca(OH)}_2 + 2 \text{H}_2$. At the ordinary temperature 1 kilo hydrolith gives 1143 litres of H_2 . It is of importance for filling military balloons.

Hydropyrine. The sodium salt of acetylsalicylic acid. It is soluble in water.

Hydroquinone (p-dioxybenzene). $\text{C}_6\text{H}_4(\text{OH})_2$. It is produced by oxidation of aniline with a chromic acid mixture. 2.5 parts powdered $\text{K}_2\text{Cr}_2\text{O}_7$ are added gradually to a cooled solution of 1 part aniline in 8 parts H_2SO_4 and 30 parts H_2O . An alkali sulphite is then added, the mixture filtered and extracted with ether. The hydroquinone is purified by boiling with animal charcoal. Colourless crystals of slightly sweet taste; M. P. 169° . May be distilled without change. Readily soluble in alcohol, ether and hot H_2O . Aqueous solutions reduce AgNO_3 solution in the cold and FEHLING'S solution on warming. Fe_2Cl_6 in small quantities colours the solution blue (the colour vanishes soon); when more Fe_2Cl_6 is added the colour disappears and small glittering green crystals appear.

Hydroquinone is used in photography and in the chemistry of colours.

Test. Distinction from pyrocatechin and resorcin:— An aqueous solution of hydroquinone is not precipitated by lead acetate. Impurities are usually inorganic substances, sulphuric acid, phenol and quinone: 1 g hydroquinone should, when heated, volatilize and leave no residue, and the cold saturated solution should not become clouded by a BaCl_2 solution. Phenol is tested for by Fe_2Cl_6 , the aqueous solutions should not turn violet, nor should a smell of phenol be noticeable on boiling. The absence of quinone is recognized by the complete colourlessness of the hydroquinone crystals.

Hydrosilicofluoric acid. H_2SiF_6 . This is obtained by heating fluorspar, silica, clay, and carbon; the gaseous SiF_4 evolved is passed into water when H_2SiF_6 is formed. On an industrial scale the SiF_4 is not absorbed in water but is passed over surfaces which are constantly kept moist.

The acid is also obtained as a by-product in the manufacture of superphosphate, and also by treating earthenware vessels with HF (the object

of treating the vessels with HF is to render them more porous.) It is further obtained in the process of purifying crude graphite with HF, the product being rectified by distillation in steam.

It is a colourless liquid which when concentrated fumes strongly in the air. It dissolves metals but not glass. The only sparingly soluble salts are K_2SiF_6 and $BaSiF_6$ which are used in analytical chemistry.

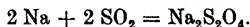
Hydrosols see „COLLOIDAL BODIES“.

Hydrosulphites. Salts of hydrosulphurous acid obtained from acid sulphites by reduction with nascent hydrogen. Usually sodium bisulphite solution is reduced with zinc and the Zn dissolved precipitated by milk of lime or soda solution. The general formula of the hydrosulphites is $M^1_2S_2O_4$.

According to the Germ. Pat. 141452 hydrosulphites are produced by means of the salts of titanium sesquioxide, e. g. Ti_2Cl_3 . When SO_2 or an acid sulphite is dissolved in water in the presence of Ti_2Cl_3 the liquid at once becomes brown in consequence of the formation of hydrosulphurous acid. Before this solution has time to decompose with separation of S it is allowed to run into NaOH, when sodium hydrosulphite $Na_2S_2O_4$ is formed, while titanium hydroxide $Ti(OH)_4$ is precipitated. The latter is used again in the process; it is dissolved in HCl and converted into Ti_2Cl_3 by electrolysis.

Recently the electrolytic methods of preparing hydrosulphites from bisulphites have become important. According to the Germ. Pat. 125207 and 129861 the cathode liquid is a bisulphite solution, as neutral as possible, and the anode liquid a solution of alkali or common salt. By this method it is possible to avoid the great losses of current caused by the secondary decomposition of free hydrosulphurous acid. The current losses are also minimized when calcium bisulphite or magnesium bisulphite solutions are used as cathode liquid; since the calcium hydrosulphite (or magnesium hydrosulphite) formed is almost insoluble and therefore escapes secondary decomposition. The other sulphites can easily be obtained from those thus prepared.

The principle of the old method is completely changed by the Germ. Pat. 148125. Metallic Na is added to cooled anhydrous ether (or benzene, ligroin, or some other medium which does not react with the alkali metals) and dry SO_2 conducted through the liquid. Instead of Na, alloys of the alkali metals and instead of SO_2 -gas, liquid SO_2 may be used. The action corresponds to the equation:



The sodium hydrosulphite is separated from the ether and an anhydrous, very stable product is obtained. The manufacture is said to be — with the present prices of Na — cheaper than the method with bisulphite and zinc-dust used hitherto.

For a considerable period attempts have been made to produce hydrosulphites in a solid stable form. According to the Germ. Pat. 112983, 125303 and 144632 solid hydrosulphites are obtained by salting out these salts from aqueous solutions with NaCl, $CaCl_2$, $MgCl_2$, $ZnCl_2$, $NaNO_2$ or $NaC_2H_3O_2$. The supplement to Germ. Pat. 133040 renders anhydrous the solid hydrosulphites thus obtained by washing with volatile liquids which mix readily with H_2O (e. g. alcohols, acetone, and even ether). Very similar to this is the method protected by Germ. Pat. 138315:— The precipitated hydrosulphites are pressed and drained, the mother liquor replaced by alcohol or other liquids which mix with H_2O and finally dried *in vacuo* over dehydrating agents, or in a current of gas free from oxygen. According to the Germ. Pat. 138093 the solid salts separated from the solution are washed with liquids like alcohols, ketones, &c., which mix with water; then the salts are stirred to a paste

with liquids such as ether, benzene, benzene, carbon bisulphide, carbon, tetrachloride, &c., which do not appreciably dissolve the products of decomposition of the hydrosulphites (mainly thiosulphates). Germ. Pat. 144281 for the preparation of solid, stable hydrosulphites should be mentioned: — 1–2 % dry zinc dust (1 to 2 %) is mixed with the hydrosulphite solution before the separation of the hydrosulphite, or it is mixed with the separated hydrosulphite. The zinc dust prevents decomposition of the preparation by oxidation.

Based on similar principles is the method of preparing perfectly stable, dry hydrosulphites protected by the French Pat. 341718 and two additional patents, and also Germ. Pat. 160529 (suppl. Germ. Pat. 162912, Germ. Pat. 171362 and 171363). The hydrosulphites are warmed above 55°C with a dehydrating liquid like alcohol, ketones, &c., when the hydrosulphite separates as an anhydrous powder which is first washed with a volatile liquid and then dried at 70°C . In certain circumstances it is well to add a little caustic soda to the alcohol.

The Amer. Pat. 756759 must be mentioned. The aqueous hydrosulphite is pressed out, dried *in vacuo* and surrounded with coal gas free from oxygen. The method offers great objections in connection with the packing and transport of the preparation.

In spite of all the methods mentioned and numerous others not here recorded, the problem of producing stable hydrosulphite compounds was not solved in a satisfactory manner. Now, however, a solution has been found by combining the hydrosulphite with formaldehyde. To whom is due the honour of having first made this important discovery is a matter of contention between KURZ of Rouen and the chemists of the cotton factory of E. ZUENDEL in Moscow, but at any rate the discovery was made practically simultaneously in various places. To produce formaldehyde-hydrosulphites, hydrosulphites — chiefly $\text{Na}_2\text{S}_2\text{O}_4$, $\text{K}_2\text{S}_2\text{O}_4$, ZnS_2O_4 and CaS_2O_4 — are mixed with 40 % formaldehyde solution, and the corresponding double salts allowed to crystallize. These formaldehyde compounds have received different names by the makers, e. g. HYDROSULPHITE NF and HYRALDITE. It appears that these products are now obtained by the action of gaseous formaldehyde on hydrosulphites. They are prepared also by treating formaldehyde and sodium bisulphite with zinc dust. These stable compounds have proved very reliable as excellent discharges in calico printing. Other names for anhydrous sodium hydrosulphite and sodium hydrosulphite formaldehyde are "ERADITE" and "RONGALITE".

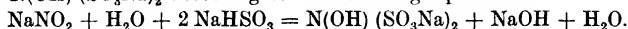
In spite of the great reducing effect of formaldehyde hydrosulphite certain dyes still resist this discharge. In order to get pure discharge effects in these cases the reducing action of hyraldite is increased according to the Germ. Pat. 166783 by adding certain metallic oxides or carbonates, e. g. ZnO , MgCO_3 , &c. The same idea is contained in the French Pat. 350607:— The hydrosulphite formaldehyde compounds are crystallized, fractionally precipitated or extracted (e. g. with methyl alcohol) or reduced with Zn. In all these cases the reducing power is said to be doubled.

According to the Germ. Pat. 162875 similar stable hydrosulphite compounds like those with formaldehyde can be obtained with acetones (acetone or methyl-ethyl-acetone) by allowing the combination to take place in presence of alkalies (preferably caustic soda and ammonia). When proper proportions are used the reaction proceeds automatically with rise of temperature. By evaporation *in vacuo* at a low temperature acetone-hydrosulphite is obtained in a solid and stable form.

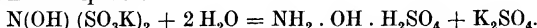
Because of their strong reducing action hydrosulphites are much used in dyeing and printing works in the preparation of hydrosulphite — indigo vats, for indigo printing and the preparation of discharge colours.

Hydrosulphurous acid see „HYDROSULPHITES“.

Hydroxylamine. $\text{NH}_2 \cdot \text{OH}$. It was formerly obtained commercially by the action of sodium nitrite on sodium bi-sulphite in concentrated aqueous solution at about 0°C . The first product is sodium hydroxylamine disulphonate $\text{N}(\text{OH})(\text{SO}_3\text{Na})_2$ according to the following equation:—



The corresponding sparingly soluble potassium salt separates from this solution on adding KCl . The substance separated is heated to $100\text{--}130^\circ$ under pressure in non-alkaline aqueous solution when it is converted into hydroxylamine sulphate:—



Hydroxylamine is now produced electrolytically according to Germ. Pat. 133457 and 137697 by reducing nitric acid under certain conditions, in presence of H_2SO_4 or some other acid. A similar process, though with modifications, is the substance of the French Pat. 322943.

Pure hydroxylamine forms crystalline needles which deliquesce in air; S. G. 1.35, M. P. 33° , B. P. (under 22 mm) 58° . Below 15°C it is fairly stable, though at higher temperatures it gradually decomposes (when heated above 100° with explosive violence).

It has a strong reducing action, is poisonous and attacks glass.

Hyoscyne. Known also as scopolamine, $\text{C}_{17}\text{H}_{21}\text{NO}_4$ an alkaloid found in various Solanaceae, particularly in the seeds of *Hyoscyamus niger* (henbane). Its salts are used medicinally, given internally or subcutaneously as a soporific, or dropped into the eye to dilate the pupil. A mixture of morphine and scopolamine is used as a narcotic. See „SCOPOMORPHINE“.

Maximum dose (internally) 0.001 g. Maximum daily dose 0.003 g.

Maximum dose for injections 0.0002. Maximum daily dose 0.001 g.

Hyoscyamine. $\text{C}_{17}\text{H}_{23}\text{NO}_3$. Alkaloid, obtained from the seeds of *Hyoscyamus niger*. It is closely related to atropine (q. v.).

White loose needles, M. P. 108.5°C . More readily soluble in H_2O and dilute alcohol than atropine, readily, soluble in absolute alcohol, ether and CHCl_3 . The solution has a sharp and bitter taste.

It is a strong poison; used medicinally in the form of its salts. It is given internally and subcutaneously as a soporific and as a sedative in cases of insanity. Dose:— 0.001 to 0.003 g. In the same quantities it is used by oculists for the same purpose as atropine. Maximum dose 0.005 g or 0.015 g per day.

Hypnal = Mono-chloralantipyrine. Obtained by the action of chloralhydrate on antipyrine.

Colourless crystals of M. P. $66\text{--}67^\circ$, readily soluble in hot, less soluble in cold H_2O . It is used medicinally as a soporific instead of chloral.

Hypnone see „ACETOPHENONE“.

Hypochlorites. For general information on the preparation of hypochlorites see the articles „BLEACHING“, „BLEACHING POWDER“ and „CHLORINE ALKALI PROCESS, ELECTROLYTICAL“.

To obtain hypochlorite solutions electrolytically the Germ. Pat. 141372 employs the corresponding chloride solutions of compounds of the metals of the alkaline earths, and small quantities of resins or resin solutions.

According to the Germ. Pat. 145745 solid hypochlorites are obtained by compressing mixtures of bleaching powder and crystalline sodium sulphate,

both substances being in the dry state. This forms NaOCl and hydrated CaSO_4 , which forms a solid mass.

According to the English Pat. 18947 of 1902 hypochlorites are solidified by drying them in an air current under reduced pressure.

* Hyposulphites see "THIOSULPHATES".

Hyraldite see "HYDROSULPHITES".

Hysterol. Another name for bornyval (q. v.).

I

Ibite. A compound of tannin and bismuth oxy-iodide. Grey-green powder, odourless and tasteless, said to be used as an antiseptic powder.

Ice see page 276. 763

Ice machines.

Ice machines:

Wegolin & Huebner A.-G., Halle a. d. S., Germany.

Ichthalbine = Ichthyol-Albumen. It is obtained by precipitating a solution of albumen with a solution of ichthyol sulphonic acid.

A fine, grey-brown powder, soluble in H_2O , insoluble in the stomach, decomposing in the intestine into ichthyol and albumen. It is chiefly used in cases of intestinal catarrh.

Ichthoform. A compound of Ichthyol sulphonic acid and formaldehyde.

Blackish-brown insoluble powder, almost odourless and tasteless. Given internally as an intestinal antiseptic. It is used externally as a substitute for iodoform in the treatment of wounds.

Ichthyol. Crude ichthyol oil, a volatile sulphurous oil containing sulphur is obtained by heating the oil-stone or stink-stone, a bituminous schist found near Seefeld in the Tyrol. By treating crude ichthyol oil with concentrated H_2SO_4 ichthyol sulphonic acid is obtained the salts of which are used therapeutically (more particularly the NH_4 -, Na -, Li -, Zn -salts).

AMMONIUM SULPHOICHTHYOLICUM as used in medicine is generally called ichthyol. Ichthyol sulphonic acid is neutralized with strong NH_3 and the product evaporated to the consistency of a thin extract.

Clear red-brown liquid of the consistency of syrup, with a smoky smell and taste, soluble in H_2O giving a clear solution. It is used medicinally in various diseases of the skin (externally), internally in cases of tuberculosis, pulmonary catarrh of the lungs, and chronic disease of the stomach and intestines.

Ichthyolidine. The piperazine salt of ichthyol sulphoric acid, given in the form of tablets in gout and uric acid troubles.

Imogen sulphite see "PHOTOGRAPHIC CHEMICALS".

Indamines. A class of coal-tar colours included amongst the quinonimide colours (q. v.). The simplest representative of these colours is "indamine" $\text{NH}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{N} : \text{C}_6\text{H}_4 : \text{NH}$, which is obtained by the oxidation of a mixture of equal molecules of p-phenylenediamine and aniline. It forms greyish-

black to greenish-blue salts, soluble in water which give a violet shade on wool mordanted with tannin or tartar emetic.

Indanthrenes. The name under which certain blue coal-tar colours are sold commercially. They are used as vat-dyes and are faster than indigo. According to the Germ. Pat. 129845 and 135407 these dyes are obtained by fusing β -amidoanthraquinone with an alkali at 200—300° C and dissolving the melt in H_2O in presence of air. The blue dyestuff so formed is insoluble in H_2O , though it dissolves in alkalies in presence of reducing agents giving a blue solution. To the same family belong:— the yellow flavanthrene, the grey melanthrene and the deep-blue cyananthrene.

Indian yellow see "PURKEE" and "COBALT COLOURS".

Indicators.

1. **LITMUS** (see "VEGETABLE COLOURS"): 1 part litmus is digested with 6 parts H_2O and filtered, exactly neutralized and again re-filtered.

2. **COCHINEAL**: 3 parts crushed cochineal are digested with 20 ccm H_2O and 50 ccm alcohol and filtered.

3. **AURINE (CORALLINE)**: 1 g aurine in 500 ccm alcohol of 80 vol. %; the solution is acid and must be exactly neutralized with baryta water before use.

4. **PHENOLPHTHALEIN**: 1 g in 75 g alcohol.

5. **PHENACETOLIN**: 25 g benzene, 30 g concentrated H_2SO_4 and 30 g acetic acid anhydride are heated under a reflux condenser. The free acids are removed by washing with cold water, and the product boiled with H_2O . The solution thus obtained is then evaporated to dryness. By dissolving the residue in alcohol the phenacetolin solution used as an indicator is obtained.

6. **METHYL-ORANGE**: 1 g in 1000 g water.

The reactions of the indicators mentioned will be found in the article "ALKALIMETRY".

Indigo. The dyestuff known from ancient times obtained from different kinds of *Indigofera* (India, China and Java). It also occurs in the European *Polygonum tinctorium* and in woad, *Isatis tinctoria*. The dyestuff occurs as a glucoside and is obtained in the free state by fermentation. During this process CO_2 is developed which reduces the dyestuff forming a yellow liquid. By vigorous stirring with paddles and oars this is brought into contact with the air, oxidation ensues, and the indigo is precipitated in blue flakes. The paste so formed is heated to boiling several times and finally all the water is expelled by pressing.

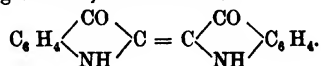
Indigo is thus obtained in dark-blue to purplish-violet masses which show a fracture with a metallic lustre. It can be easily powdered.

An improvement on the above process is described in French Pat. 323036. According to this the indigo plant is macerated and treated with tannin. Pure indigo blue is precipitated and the impurities remain in solution. The active constituent is indigo blue.

For details concerning indigo dyeing &c. see „INDIGO DYESTUFFS“ and „VATS AND VAT DYESTUFFS“.

Indigo dyestuffs. The chromophore of this class of colours is supposed to

be the group $R \begin{array}{c} \diagup CO \\ \diagdown NH \end{array} C =$; it is found duplicated in indigo blue. The constitution of this substance, which is the principal representative of this class of colouring matters, is as follows:—



It must be added that the molecular weight 524 of indigo, lately determined by experiment, should double the above formula.

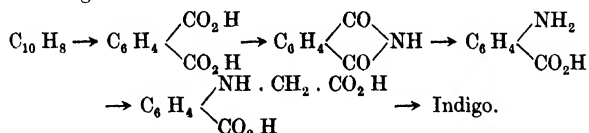
A. The manufacture of Indigo.

A great number of methods have been brought forward for the synthesis of indigo of which, however, only a few have proved of practical importance. The number of patents dealing with the synthesis of indigo and allied substances increases annually to such an extent that it is now difficult to distinguish between the valuable and the less important.

We shall here for convenience' sake divide the synthetic methods into three groups, according to the substance from which the indigo is made.

1. SYNTHETIC PRODUCTION OF INDIGO FROM NAPHTHALENE.

The largest amount of artificial indigo brought into commerce is probably manufactured by a process patented by HEUMANN (Germ. Pat. 91202). Naphthalene is oxidized with H_2SO_4 in presence of salts of Hg to phthalic acid; this is then converted into phthalimide which is further converted into anthranilic acid. The anthranilic acid is condensed with chlor-acetic acid, thus forming phenylglycocollorthocarbonic acid. This product is then fused with caustic alkali, the melt dissolved in water and finally the indigo separated by oxidation with atmospheric oxygen. The phases of the process are given in the following formula.



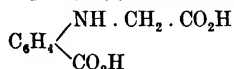
The synthesis of indigo from phthalic acid or anthranilic acid has undergone many modifications. The phthalic acid is obtained (Germ. Pat. 134410) from α -nitro-naphthalene by heating the latter first with alkalis and oxidizing metallic oxides. It is thus converted into nitronaphthol and on again heating the product with alkalis a mixture of benzoic and phthalic acids is formed. It is not very probable that this method will supersede the older one described by HEUMANN.

According to Germ. Pat. 130301 and 130302 the anthranilic acid is obtained from phthalyl hydroxylamine. This compound, which according to Germ. Pat. 130680 and 130681 can be easily made from phthalic acid anhydride and hydroxylamine in alcoholic solution, is changed at once into anthranilic acid by treatment with NaOH solution. The same process is protected by the French Pat. 318050. The Germ. Pat. 135836 and 136788 do not differ essentially from the methods by which anthranilic acid is obtained from free phthalyl hydroxamic acid. The latter acid is prepared from hydroxylamine by the action of phthalic acid anhydride in aqueous solution; the phthalyl hydroxamic acid is then converted into anthranilic acid by boiling with an alkali or alkaline carbonate. The process protected by the Germ. Pat. 129165 seems to have become of technical importance. By this method the anthranilic acid is obtained from its sulphonic derivatives; sulphanthranilic acid is decomposed giving anthranilic acid by the addition of sodium amalgam. As, however, the sulphanthranilic acid is obtained indirectly from toluene, this process will be further described below.

Another substance should also be mentioned here as a starting point in the manufacture of anthranilic acid. Germ. Pat. 102068 and 139559 protect a method for obtaining this substance from phthal-chlorimide by passing HCl into water containing phthalimide in suspension. The phthal-chlorimide

yields anthranilic acid when digested with dilute caustic soda (Germ. Pat. 133590).

A modification of HEUMANN'S method of converting anthranilic acid into phenylglycocoll-carbonic acid is given in Germ. Pat. 117924 and 120136. $C_6H_4(NH_2) \cdot CO_2H$, anthranilic acid, is converted by the action of formaldehyde and hydrocyanic acid into ω -cyanmethylantranilic acid, that is the nitrile of phenylglycocoll carbonic acid, from which the acid itself is obtained by saponification. From the phenyl glycocoll-o-carbonic acid



the indigo is prepared by fusing with caustic potash at first in the absence of air. Afterwards air is passed into the solution of the melt. Modifications of this method are given by Germ. Pat. 123695 and 158346. The separation of the indigo by passing air into the solution of the melted substance is protected by Germ. Pat. 120900. Germ. Pat. 152548 describes what appears to be a better method, by which the phenyl glycocoll carbonic acid may be directly converted into indoxyl by fusing with alkali *in vacuo*. The indoxyl is then converted into indigo by blowing air through the mixture.

According to Germ. Pat. 158089 it is easier to convert the dialkylesters or the diamido derivatives of phenylglycocoll carbonic acid than the free acids into indoxyl, by heating them with sodamide in benzene solution. Some similar solvent may be used. The sodamide used in this process is described later.

The above-mentioned method of converting anthranilic acid into ω -cyan-methyl anthranilic acid by the action of formaldehyde and hydrocyanic acid, can (according to Germ. Pat. 155628) be more advantageously carried out if the formaldehyde and anthranilic acid are first condensed and the product of this condensation treated with sodium bisulphite. The acid sodium salt

of the ω sulphomethyl anthranilic acid $C_6H_4 \begin{cases} NH \cdot CH_2 \cdot SO_3Na \\ COOH \end{cases}$ is formed.

The latter can be transformed directly by a metallic cyanide into ω -cyan-methyl anthranilic acid.

Another method for the preparation of phenyl glycocoll-o-carbonic acid is protected by Germ. Pat. 125456, 142506, and 142507. The above acid is obtained from o-chlorbenzoic acid and glycocoll by heating the alkaline salts of the components in a dry state to 220° or by boiling them in aqueous solution for from 4 to 6 hours. Should the latter method be followed the reaction is favourably influenced by the addition to the solution of copper- filings and alkaline carbonates. The supplementary Germ. Pat. 143902 (orig. Germ. Pat. 142507) states that the oxalyl compounds of glycocoll can be used instead of glycocoll itself. The oxalyl di-glycocoll provides a convenient method for preparing pure glycocoll on account of its insolubility in water. If molecular quantities of o-chlorbenzoic acid and oxalyl di-glycocoll in the form of their alkali salts are heated a good yield of phenyl glycocoll carbonic acid results and not, as might be expected, oxalyl di-phenyl glycocoll di-o-carbonic acid. The success of this process depends upon the existence of a cheap method for the manufacture of o-chlorbenzoic acid (q. v.).

2. THE PREPARATION OF INDIGO FROM ANILINE.

For some time methods for the preparation of indigo from aniline have been known and indeed practised. Indigo can be obtained (Germ. Pat. 54626)

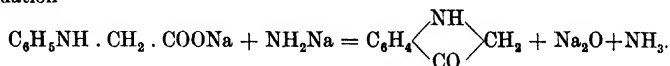
by fusing phenyl glycooll, $C_6H_5 \cdot NHCH_2 \cdot CO_2H$ with caustic potash at first in the absence of air, with later oxidation of the solution of the melt by means of a current of air. Phenyl glycooll, which can also be regarded as phenyl-amidoacetic acid, was obtained by the action of chloracetic acid on aniline. It seems, however, as if this synthesis remains only of theoretical interest, partly because of the poor yield from the fused phenyl glycooll and partly on account of the considerable difficulties presented in practice by the apparently simple conversion of aniline and chloracetic acid into phenyl amidoacetic acid. It is true that by the method protected by the French Pat. 317121 the yield of phenyl glycooll from chloracetic acid and aniline can be trebled by observing certain technical details in working, but still the result seems not sufficiently satisfactory for the process to hold its own, for the application for the German patent has been withdrawn. The prospects for the synthetic production of indigo from aniline have meanwhile improved as a result of other circumstances. According to Germ. Pat. 132621 a process has been discovered for the manufacture of *o*-cyanmethyl aniline, that is the nitrile of phenyl glycooll. The bisulphite compound of anhydroformaldehyde aniline is converted by KCN into *o*-cyanmethylaniline. According to French Pat. 315269 the same compound is still more simply obtained from aniline hydrochloride formaldehyde, HCl and KCN. By the saponification of the nitrile (i.e. *o*-cyanmethyl aniline) phenyl glycooll itself is formed. In order to obtain the salts of phenyl glycooll in one operation aniline is treated with formaldehyde and KCN in dilute alcoholic solution, without the addition of acid. This process is registered as French Pat. 135332. A modification of this method protected by Germ. Pat. 145376 recommends that the reaction should be carried out in alkaline alcoholic solution. Further the Germ. Pat. 156760, a modification of Germ. Pat. 132621, should be here mentioned.

The Germ. Pat. 157617 also deals with the same subject. A solution of KCN is treated with HCl and anhydro-formaldehyde aniline is added in the proper proportions, the mixture is heated for two hours on a water bath, *o*-cyanmethyl aniline being formed. In principle, the French Pat. 315269 is similar. That improvements are possible in this line is shown by the registration of the Germ. Pat. 157710 according to which aniline hydrochloride and KCN react in ether or ligroin solution in presence of acetone. The nitrile is thus formed directly. Finally mention must be made of Germ. Pat. 157909 according to which formaldehyde is first condensed with bisulphite and then aniline is warmed with the formaldehyde bisulphite thus produced. The sodium methyl-aniline-*o*-sulphonate formed is treated with KCN when *o*-cyanmethyl aniline is formed. Recently considerable improvements in the manufacture of phenyl glycooll have been introduced. According to Germ. Pat. 167698 chloracetic acid is treated with excess of aniline in presence of lime or magnesia (an excess of basic substances, except aniline, must be avoided).

A good yield is obtained (Germ. Pat. 177491) by the action of aniline upon chloracetic acid at the moment of liberation of the acid from a salt of one of the heavy metals. This process is carried out by warming aniline and chloracetic acid in saturated salt solution in presence of the oxide or carbonate of a heavy metal (e. g. ferric hydroxide). This is similar to French Pat. 375055. Phenyl glycooll may also be obtained (Germ. Pat. 175797) by warming nitrobenzene with iron and chloracetic acid.

Despite these various new methods it does not seem as if the synthetic production of indigo from aniline by means of phenyl glycooll will prove successful, since only a poor yield of indigo is obtained by fusing phenyl glycooll with caustic alkali. According to Germ. Pat. 138903 the yield is considerably increased if the fusion with alkali is conducted in presence of an alcoholate; and according to French Pat. 322536 sodium or alloys of Sn, Pb, &c. with Na, and also lime should be added to the fusion mixture. The French Pat. 319670

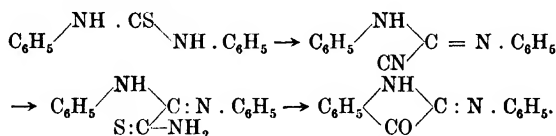
recommends in preference to the above, the addition of caustic baryta or caustic lime to the NaOH. All these processes for the conversion of phenyl glycooll into indigo have, however, been pushed into the background by Germ. Pat. 137955 in which sodamide is used as a condensing agent. The sodamide, NaNH_2 is either melted and the glycooll then introduced or the powdered amide is mixed with the glycooll and then placed in a vessel heated to the requisite temperature. See „SODIUM COMPOUNDS“. The reaction, in which the escaping NH_3 prevents the harmful effects of the air, corresponds to the equation



The improvement in the yield compared with that obtained when caustic alkali is used is due to the fact that the NaNH_2 melts at a much lower temperature than NaOH and acts on the glycooll at its melting point, while the high temperature needed for fusing the alkali destroys a large portion of the glycooll. The indoxyl produced in this way is dissolved and subjected to oxidation, when indigotine is formed. Germ. Pat. 149638 protects a special process of oxidation of the fused leuco-compound. The action is carried out in aqueous solution in presence of alkali nitrates by a strong current of air or oxygen. According to French Pat. 343078 the phenyl glycooll is heated to 230° with caustic alkali in a current of hydrogen, or the heating is carried out *in vacuo* with caustic potash and metallic Na. The indoxyl formed is dissolved in H_2O and the indigo precipitated by blowing in air.

SANDMEYER'S extremely interesting and promising process also starts from aniline. Diphenylthiourea is obtained from aniline and CS_2 ; this is then converted into hydrocyanocarbodiphenylimide by simultaneous treatment with KCN and white lead (lead carbonate). The product is converted by means of yellow ammonium sulphide into a thioamide. If this is warmed with concentrated H_2SO_4 , NH_3 and H_2S are evolved and α -isatinanilide is formed.

The reactions are as follows:—



From isatinanilide indigo is formed by reduction with ammonium sulphide. According to Germ. Pat. 131934 if H_2S is allowed to react with α -isatinanilide in acid solution α -thioisatine and aniline are formed. Thioisatine is an unstable body which decomposes into sulphur and indigo on the addition of alkalies, alkali carbonates, &c. If on the other hand isatinanilide is treated

with dilute H_2SO_4 , aniline separates and isatine, $\text{C}_6\text{H}_4 \begin{array}{c} \text{N} \\ \diagup \quad \diagdown \\ \text{CO} \end{array} \text{C}(\text{OH})$, one of

the products of the oxidation product of indigo, is formed. It is easily prepared by this method.

3. SYNTHETIC PRODUCTION OF INDIGO FROM TOLUENE.

This method is also of industrial importance. Formerly toluene was necessary in the preparation of anthranilic acid (toluene \rightarrow o-nitrotoluene \rightarrow o-toluidine \rightarrow o-acettoluidide). The last named compound on oxidation

with KMnO_4 gives anthranilic acid. The process, however, cannot compete with the synthesis from naphthalene.

Indigo is obtained from toluene in the following stages:—toluene \rightarrow o-nitrotoluene \rightarrow o-nitrobenzaldehyde \rightarrow o-nitrophenyl lactic acid methyl ketone \rightarrow indigo. The difficulty in this process lies in the preparation of the o-nitrobenzaldehyde. As a rule the o-nitrotoluene is treated with chlorine; the product, o-nitrobenzylchloride, is condensed with aniline; the result, o-nitrobenzylaniline, is oxidized to benzylidene compounds, after which the last named substance is decomposed giving as a final product o-nitrobenzaldehyde. This process, patented by the "Höchst Farbwerke", as well as the other methods given, are all very complicated; a new patent lately registered claims, however, to prepare in one operation o-nitrobenzaldehyde from o-nitrotoluene; manganese dioxide and H_2SO_4 are used so that great simplification and economy are attained. The other parts of the synthesis in question are not difficult to perform. The conversion of nitrophenyl lactic acid ketone into indigotine takes place quite easily and almost quantitatively. The o-nitrophenyl lactic acid ketone is obtained by the condensation of o-nitrobenzaldehyde with acetone in alkaline solution. An improvement in this condensation process is treated of in Germ. Pat. 146294. The o-nitrophenyl lactic acid ketone may be applied to the fibres and subsequently converted into indigo, but extended use of the ketone is prevented owing to its slight solubility in H_2O . The nitrophenyl lactic acid ketone can be made soluble by acetic acid, or still better by aromatic sulphonic acids. The use of the latter compounds for this purpose is protected by Germ. Pat. 148943 and the English Pat. 11522 (1902). A still better method of dissolving the nitrophenyl lactic acid ketone is protected by Germ. Pat. 160783. According to this patent it has been found that the above mentioned ketone forms with the alkaline salts of benzylaniline sulphonic acid, $\text{C}_6\text{H}_5 \cdot \text{CH}_2 \cdot \text{NH} \cdot \text{C}_6\text{H}_4 \cdot \text{SO}_3\text{H}$, a compound which readily dissolves in H_2O , and is very stable.

The above-mentioned process protected by Germ. Pat. 129165 also belongs to the synthetic production of indigo from toluene. Anthranilic acid is obtained from its sulpho-derivates, the sulphoanthranilic acid being composed by sodium amalgam into anthranilic acid. This latter compound is then converted through phenylglycocoll carbonic acid into indigo in the manner described above.

Sulphoanthranilic acid is obtained (Germ. Pat. 138188) by boiling o-nitrotoluene sulphonic acid with caustic soda solution, when reduction of the nitro-group and oxidation of the methyl-group take place simultaneously. Instead of converting sulphoanthranilic acid into anthranilic acid with sodium amalgam, Germ. Pat. 143141 proposes to convert the acid into phenylglycocollsulphocarbonic acid by means of chloracetic acid or formaldehyde and hydrocyanic acid and then to fuse this product with caustic soda. At a temperature of $220-230^\circ$ a mixture of indigo and indigo sulphonic acid is obtained, whereas if the temperature be raised to $310-340^\circ$ indigo alone is formed. Germ. Pat. 154524 modifies the process of Germ. Pat. 143141 in one point, namely the diphenylglycocollsulphocarbonic acid is fused with sodamide instead of with caustic soda. The reaction takes place at a much lower temperature. If the temperature is then raised to $200-220^\circ$ no indigo sulphonic acid is formed.

According to Germ. Pat. 146716 the sulpho-group of the sulphoanthranilic acid can be removed by electrolysis in cathode chambers. The supplement to Germ. Pat. 147228 extends the same electrolytical reaction to the phenylglycocollsulphocarbonic acid which can be obtained from the sulphoanthranilic acid, the result being phenylglycocoll-o-carbonic acid.

B. Purification and properties of Indigo.

Both natural and synthetic indigo contain impurities which must be removed before the product can be used for most purposes.

A process that has been used for some time, is to boil it with a mixture of concentrated acetic acid and concentrated H_2SO_4 when the indigotine alone dissolves as indigotine sulphate. It is freed from impurities by filtration, and by the addition of large quantities of water the indigo sulphate in the filtrate is decomposed, the indigotine being precipitated. This process, however, since large quantities of both acids are necessary, is only adapted for industrial purposes, when the materials can be subsequently recovered. To accomplish this according to Germ. Pat. 156829, the H_2SO_4 in the mixture of indigo, sulphuric acid and acetic acid is treated with anhydrous Na_2SO_4 or $\text{NaC}_2\text{H}_3\text{O}_2$ without the addition of water. The acetic acid is then distilled off, the bisulphate dissolved by adding a little water, and the residual indigo bisulphate finally obtained by crystallisation.

According to Germ. Pat. 134139 the crude indigo for purposes of purification is extracted on a boiling water bath with pyridine bases. Germ. Pat. 148114 recommends the heating of the indigo to a temperature below the point of sublimation and decomposition (i. e. 200° — 270°). In this way the red impurities are destroyed and the synthetic indigo acquires the bronze tone which is so highly valued by most buyers. For a modification of this process see supplement Germ. Pat. 179351. According to Germ. Pat. 158500 the impurities again are removed by extraction with phenol or phenol esters in such proportions that only the impurities are dissolved and the indigo itself remains practically unaffected.

According to Germ. Pat. 147162, 149460 and 157541 indigo is obtained in the dry state by mixing indigo paste with starch and indifferent substances such as magnesia, clay, chalk, &c. If instead of these mixtures sugar molasses, glycerine, gelatine or laminaria ¹⁾, is used dry indigo can be treated in the same way. The mixture is pressed after filtration, moulded and dried at a low temperature. Very finely divided indigo is obtained (Germ. Pat. 170978) by adding to the alkaline solution of the leuco compound small quantities of fatty or resin acids before oxidation takes place. In this way the oxidation takes place in presence of soaps.

Finely divided indigo in a moist state (highly concentrated indigo paste) can be obtained by mixing with carbohydrates (molasses, &c.) and evaporating to a thick paste (French Pat. 361357). The preparation is stable and requires the addition of no preservatives.

Indigo is insoluble in all the ordinary solvents. It has no affinity for animal or vegetable fibres and can only be fixed on the fibre by vat dyeing (q. v.). If indigo is dissolved in fuming H_2SO_4 a deep blue solution is obtained, which is no longer pure indigo but indigo sulphonic acid. By neutralisation of the dilute filtered solution with soda (common salt being also added) the sodium salt of indigo sulphonic acid is obtained. This is sold as indigocarmine or soluble indigo blue. It is soluble in cold water. Indigocarmine is obtained synthetically by dissolving phenylglycocoll in fuming H_2SO_4 at a low temperature, and then oxidizing the mixture. It is interesting to note that MOEHLAU has recently obtained colloidal indigo which dissolves in H_2O to a clear deep blue fluid. His method is to warm indigo in suspension in a solution of caustic soda and sodium hydrosulphite in presence of air. The clear solution is, after cooling, treated with lysalbinic acid or protalbinic acid (see PROTALBINIC ACID). It is then filtered and the filtrate oxidized with H_2O_2 . In this way the indigo is obtained in a form soluble in water. It can be recovered by evaporation without losing this property.

By the use of colloidal indigo solutions, dyeings can be obtained which as regards fastness to light and rubbing are quite equal to those produced in the

¹⁾ A kind of sea-weed.

ordinary way. Since however the indigo is more or less deposited on the surface only, these dyeings are not fast to soap and milling.

C. Substituted Indigo derivatives.

Substituted indigo preparations are becoming increasingly important. Of these preparations the most important is bromindigo, for the manufacture of which so many patents have been taken out that only the most important can be here mentioned.

According to Germ. Pat. 128575 and 149941 liquid bromine or bromine vapour is allowed to act upon indigo in the dry state or in presence of moisture. According to Germ. Pat. 149940 bromindigo may be prepared by intimately mixing the indigo with bromine starch. With the same object indigo is treated with pyridine bromide, $C_5H_5NBr_2$ (Germ. Pat. 149899). According to Germ. Pat. 149983, indigo or indigo white is electrolyzed with or without a diaphragm. The aqueous or sulphuric acid suspension of indigo is then treated with hydrobromic acid, or with bromides. Further, according to Germ. Pat. 144249 and 145910 indigo white or its sodium compound may be treated with bromine and the resulting bromindigo white oxidized in the usual way to bromindigo.

According to Germ. Pat. 149941 the process of treating with Br is carried out in presence of H_2O . The same principle, with modifications, is described in Germ. Pat. 149989, 151866, 158511, 154338, 160817, 161463 and 162670.

Bromindigo is apparently not destined to become of very great importance for dyeing purposes. It yields a bright violet-blue shade which is faster to light and steaming than pure indigo colours. It can also be shaded with indigo to any desired extent.

According to Amer. Pat. 856776 and 856687 tri- or tetrabromindigo may be obtained by treating indigo with definite amounts of bromine at a temperature of 225° in presence of certain solvents such as nitrobenzene. (The preparation is also protected by French Pat. 375514.) It should prove of great value on account of its brilliancy of shade, exceptional fastness to chlorine and the readiness with which the vats may be prepared.

Chlorindigo also seems to be of value. See Germ. Pat. 164384, 165149, 167771, 167830, 168683, and Amer. Pat. 812598.

Of lesser importance are other substituted indigos, e. g. dinitroindigo, naphthaleneindigo, &c.

In the conversion of phenylglycocoll into indigo or indigocarmine an intermediate product, indoxyl, $C_8H_5\left\langle \begin{smallmatrix} (OCH) \\ NH \end{smallmatrix} \right\rangle CH$, is produced. The car-

bonate of indoxyl, indoxylic acid, $C_8H_7NO_3$, is sold under the name of indophor. The alkaline solution when shaken in presence of air yields indigo. Indophor is used for blue printing. Indoxyl can be obtained (Germ. Pat. 79409 and 137208) from methylantranilic acid by heating with caustic alkalis (better in presence of sodamide). See also Germ. Pat. 138903, 142700, 145601 and 163039, French Pat. 209567, 328148, 340695 and 348980, Amer. Pat. 776884, &c. The most important methods have been mentioned above in the paragraphs dealing with the preparation of indigo.

Dyeing with indigo must be carried out in vats. The indigo is first reduced to indigo white; the solution of the latter in alkaline liquids is called the indigo vat. According to Germ. Pat. 139567 the reduction of the indigo to indigo white is carried out by electrolysis in presence of hot sulphite solutions, the anode chamber containing H_2SO_4 . The indigo white so prepared keeps well and may be transported without change. Germ. Pat. 153577 describes

a process for the preparation of indigo. Anthranilic acid is heated in molecular proportions with glycolid or glycollic acid, and the product of the reaction then fused with caustic alkali. A leuco compound is thus obtained which on oxidation yields indigo.

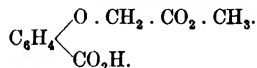
According to French Pat. 349379 indoxyl or indoxyllic acid is converted into indigo white by treating it with an aqueous suspension of indigo while air is blown through. Small quantities of ferrous salts or alkaline sulphides facilitate the reaction. Interesting compounds of indigo are obtained (Germ. Pat. 158625) by treating indigo with concentrated aqueous or alcoholic solutions of alkalis or alcoholates. The compounds are obtained in the form of a dry greenish powder which is stable and only slightly soluble in alcohol. It is decomposed by water. The indigo separated by treatment with water is especially adapted for the preparation of vats.

If a fibre is dipped into an indigo vat, the indigo white is deposited in the fibre and is there converted into indigo blue by atmospheric oxygen. See „VATS“ and „VAT DYE STUFFS“.

Indium and Indium compounds.

INDIUM. In. A. W. = 114. A rare silver-white metal, found with zinc and obtained from zinc blende. It is softer than lead, very ductile and capable of taking a high polish. S. G. (at 17° C) 7.4; M. P. 176°. Dissolves in dilute HCl and H₂SO₄, more rapidly in HNO₃. Indium, like its compounds is of little importance.

Indoform = Salicylic acid methyleneacetate.



White powder M. P. 108—109°, said to be given in doses of 0.5—1.5 g for gout, neuralgia, and rheumatic diseases.

Indol. $\text{C}_6\text{H}_4 \begin{cases} \text{CH} \\ \text{NH} \end{cases} \text{CH}$. May be obtained in various ways, e. g. by

distilling indigo blue with zinc dust. VORLAENDER and APALT recommend reducing indoxyllic acid or indoxyl with sodium amalgam in alkaline solution and then distilling with steam in a current of CO₂. The indol passes over partly in the crystalline state (M. P. 52°) and partly dissolved in the distillate from which it can be separated as the picrate.

According to German Pat. 152683 organic compounds of the type R . N . CH₂ . CO (where R is an aromatic radical), such as phenylglycocoll, its carbonic acid &c., are converted into indol and its derivatives by treatment with oxides or hydroxides of the metals of the alkalis or alkaline earths. The indol contained in the melt is combined with alkali and mixed with indoxyl derivatives. In order to separate it the indoxyl derivatives are oxidized to indigo, the indol extracted from the filtrate by means of ether or benzene, and precipitated with picric acid.

The yield rises with the temperature, especially when finally divided iron, sulphites or other suitable reducing agents are added to the melt.

Another patented method is of this nature:— o-nitrotoluene → o-nitrobenzylchloride → o-nitrostilbene → o-amidostilbene → indol.

Indophenols. A class of coal-tar colours included in the quinonimide group (q. v.); they are closely related to the indamines (q. v.). Indophenol must be regarded as the oxidation product of dimethyl-p-amidophenyl-4-amido-1-

naphthol. According to the Germ. Pat. 15925 (expired) they may be produced by the simultaneous oxidation of phenols and p-amidophenols with alkaline oxidizing agents. An improvement of this process is the object of Germ. Pat. 157288.

Blue indophenol is reduced to indophenol white by reduction with tin acetate. It is fixed on the fibre by vat dyeing (q. v.).

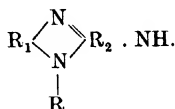
A new method of preparing indophenols which is of commercial importance (French Pat. 330388, 332884, and 345099) consists of condensing nitroso-phenols in the presence of an acid with amines in which the para position is unoccupied. The concentration of the acid appears to play an important part.

See also Germ. Pat. 160710, 168229 and 170128.

Indophor see "INDIGO DYES".

Indoxyl see "INDIGO DYES".

Indulines. A class of coal-tar colours belonging to the azines (see "AZINE DYE STUFFS"). They are p-quinonimide derivatives containing the chromophore:—



Concerning the nomenclature of these colours all those obtained by heating amidoazobenzene or azobenzene with aniline or aniline salts (induline melt) are called indulines, while nigrosines are the indulines obtained from nitrobenzene or nitrophenol.

Rosindulines see "SAFRANINES".

Inertol see „SPINNING OILS“ under „OIL“.

Infusorial earth (KIESELOUR). The siliceous remains of Diatoms. A soft white or greyish powder. It is sold, after sorting according to colour, washing and calcining, as a non-conducting material for enveloping steam boilers and steam pipes, as an absorbent for liquids, liquid manures, for treating damp walls, in the preparation of dynamite (q. v.), and as a filling material in the manufacture of soap, dyes, blotting paper, rubber goods, &c. See also "DIATOMITE".

Infusorial earth:

C. W. Reye & Söhne, Hamburg.

Ingrain colours. They are obtained from Primuline (see "THIOBENZENYL DYE STUFFS") by treating dyed material with various developers. Unmordanted cotton is dyed with primuline yellow, diazotized on the fibre and then treated with β -naphthol (red developer (which produces ingrain red). Developing with benzylnaphthylamine (Bordeaux developer) produces ingrain bordeaux and developing with m-phenylenediamine gives ingrain brown. Other developers have been described by which ingrain orange, ingrain yellow, ingrain maroon, and ingrain crimson can be obtained

Insect blossoms (FLORES PYRETHRI). These flowers which belong to the chrysanthemum group (*Pyrethrum*) are dried and sold for various purposes. There are numerous varieties, which are broadly divided into Persian and Dalmatian kinds. Another variety found only in North America is imported

into Europe under the name of Transatlantic Pyrethrum. The oriental kinds (Persian) have long, oval, green or greenish-brown enveloping leaves, deep rose-coloured or white radiating petals 15 mm in length and yellow, pipe-formed, five-pointed styles. The Dalmatian blossoms have a yellow brown involucre and styles 6 mm in length; the seed shell is also much larger than that of the oriental variety.

Insulation. A distinction is drawn between heat insulation and electrical insulation.

As non-conductors of heat the following are used:—

tow, silk, slag-wool, wood-wool, asbestos, saw-dust, papier maché, clay, clay mixed with straw, ashes, cork, sand, charcoal, felt, cowhair, moss, spone, asphalt, kieselgur, &c.

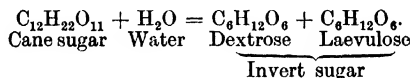
The BERKEFELD insulating substance is a mixture of kieselgur and cowhair: KNOCH's patent preparation is prepared from wood, jute, wool, argillaceous shale (killas) and animal glue. LEROY's mixture is composed of clay, hemp and cocoanut fibres, wool refuse, paper pulp, charcoal, saw-dust, flour and tar. By fermentation the mass is made uniform and adhesive. Glass plates and asbestos felt are also used. Mixtures which contain organic matter are steeped in solutions to render them non-inflammable. See „URALITE“.

Cork-stone products are valuable for this purpose. See also „DIATOMITE“.

For electrical purposes caoutchouc, guttapercha, porcelain, &c. are most important. Germ. Pat. 147688 protects a preparation of soaps used either alone or mixed with rubber, guttapercha, &c.

Invar see „NICKEL ALLOYS“.

Invert sugar. A mixture of molecular proportions of grape sugar (dextrose) and fruit sugar (laevulose), obtained by the action of dilute acids on cane sugar:



As laevulose turns the plane of the ray of polarized light more to the left than dextrose does to the right, invert sugar being a mixture of equal molecules is laevorotatory, while cane sugar itself is dextrorotatory, consequently „inversion“ has occurred.

In consequence of its valuable properties invert sugar is prepared in various ways; according to the Germ. Pat. 57368 in the following manner: A solution of cane sugar is brought to boiling point in a closed vessel and then injected into another closed vessel by means of an injector worked with CO₂ at a pressure of at least 4 atmospheres. This second vessel contains CO₂ at $\frac{1}{4}$ to $\frac{1}{2}$ atm. pressure. It is in this stage of the process that the sugar in the form of spray is inverted.

According to Swedish Pat. 14979 (1902) a pure, pale syrup of agreeable taste may be prepared from molasses: The acidified sugary mass is added to a more or less inverted solution of sugar prepared from sugar with a low percentage of ash obtained from the original sugar-substance.

Pure invert sugar is a colourless syrup from which a little dextrose gradually separates when exposed to light. It is sweeter than cane-sugar, of more agreeable taste than sugar candy and is directly fermentable. It is used to improve wine, in the manufacture of champagne, liqueurs, fruit preserves, and honey-substitutes.

Iodine. I. Atomic weight = 126.98. This element, chiefly obtained from the ash of certain kinds of sea-weed, belongs to the group of halogens. Recently

equally large quantities have been obtained from the crude Chili saltpetre, which always contains some of this substance; iodine is further produced from phosphorites which usually contain this element.

The sea-weed which is either washed ashore, or directly cut and harvested from the water, is dried in the sun and then burnt. The ashes are technically known as kelp or varec and contain the iodine as NaI. The ash is lixiviated in definite proportions by a special method, and the salts which pass into solution are separated by fractional crystallization. The concentrated mother liquor when purified and freed from the heavier soluble salts is distilled in patent stills with manganese dioxide and H_2SO_4 . Another method is to extract the iodine by passing Cl into the mixture. According to English Pat. 15233 (1900) iodine is obtained by treating sea-weed at a high temperature with dilute H_2SO_4 . The I can then be separated by well-known chemical methods, either by lixiviation or by oxidation with NaNO_2 and distillation. The K_2SO_4 remaining in the solution is afterwards separated by crystallization.

Chili saltpetre contains iodine principally in the form of sodium iodate, but partly as sodium iodide. The iodine from saltpetre is extracted from the mother liquors obtained in refining the crude saltpetre. SO_2 is passed into the solution thus causing the separation of the I from the sodium iodate. If chlorine water is added the iodides are also decomposed. The iodine settles as a black muddy substance, which is filtered, washed, and dried by draining in a porous gypsum box. The crude iodine thus obtained which contains about 80 % of the element is then purified by distillation with steam.

The electrolytic methods employed for the preparation of bromine are also applied to the extraction of iodine from liquors containing this element. The iodine is in fact extracted before the bromine. Compare „BROMINE“, French Pat. 361499 describes the extraction of iodine with vaseline oils. The iodine is recovered by extraction with sodium sulphite. From the extract it is set free by treatment with nitrites or chlorates. See Germ. Pat. 182298.

Iodine is purified by sublimation at the lowest possible temperature. It is brought on the market in small covered bottles.

Iodine occurs as flexible, greyish-black cakes with a metallic lustre, which have a peculiar and disagreeable odour. It attacks the skin forming blisters and colours it red-brown. S. G. 4.95; M. P. 113—115°; B. P. 180°. One part of iodine dissolves in 4000—7000 parts of H_2O . It dissolves readily in alcohol (TINCTURE OF IODINE) in ether, hydriodic acid, potassium iodide solution, benzene, potassium hydroxide, &c.

TEST. The solubility in alcohol and in KI solution and complete volatilisation in air are considered proofs of the purity of iodine, but are in no way reliable tests.

A quantitative determination of the J by titration with sodium thiosulphate or arsenious acid is a far more practical test. For carrying out the experiment 10 g of a finely powdered average sample is dissolved in an aqueous solution of KI (1000 ccm), and 50 ccm of the solution is then titrated. Standard $\text{Na}_2\text{S}_2\text{O}_3$ or As_2O_3 solution is then added in excess and the mixture titrated with N/10 iodine solution (with starch paste as indicator) until a weak blue colour appears.

Iodine compounds. Iodides and iodates will be found separately under the respective metal or alkyl-compounds, e.g. ammonium iodide under „AMMONIUM COMPOUNDS“, ethyl iodide under „ETHYL COMPOUNDS“, &c.

Iodine compounds:

Willy Manger, Dresden, Germany.

Iodipine. A compound of iodine and sesame oil. It is sold as 10 % and 25 % iodipine (containing 10 % and 25 % iodine respectively), an oily yellowish or brownish liquid used instead of KI in syphilis.

Iodoacetone. $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_2\text{I}$. Formed when I is dissolved in acetone. Can be used in the treatment of carbuncles.

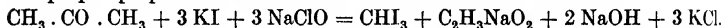
Iodoanisol see "ISOFORM".

Iodofan. $\text{C}_6\text{H}_3\text{I}(\text{OH})_2\text{H} \cdot \text{COH}$. A condensation product of formaldehyde and iodoresorcin. It is an amorphous tasteless and odourless powder, of the colour of red sealing wax. Insoluble in water, ether, chloroform, &c. Used as a substitute for iodoform. It combines the properties of this latter substance and of resorcin.

Iodoform. CHI_3 . Obtained by warming alcohol, iodine and an alkali (or alkaline carbonate):



In another process KI acetone and caustic soda are dissolved in water in the proper proportions and treated with dilute NaClO solution:



According to LE COMTE (Chem. Ztg. 1902, Repert. 278) alcohol or acetone may be replaced by acetylene. A white precipitate is obtained by treating an aqueous solution of HgCl_2 with C_2H_2 , the constitution of which is $\text{Cl} \cdot \text{Hg} \cdot \text{CH} : \text{CH} \cdot \text{Cl}$. Iodine and caustic soda are allowed to act on the precipitate (which latter may be replaced by acetylene compounds of Ag, Cu, &c.) and CHI_3 is formed.

According to Germ. Pat. 29771 CHI_3 may be obtained by the electrolysis of a mixture of alcohol and an aqueous solution of potassium iodide in presence of CO. Recently it has been obtained electrolytically from a mixture of aqueous KI solution and acetone; according to the latest reports the method appears to be one of commercial importance.

Yellow shining leaves or plates, greasy to the touch, with a penetrating disagreeable smell. S.G. 2.0; B.P. 119°; volatile in steam. It is used internally as an antiseptic, but is mainly employed for external treatment.

Test. To estimate iodoform quantitatively 1 g of the finely powdered substance is heated in a 250 ccm measuring flask with frequent shaking, on a boiling water bath for one hour with 100 ccm N/10. AgNO_3 solution. The yellow substance then adhering to the sides of the flask is washed back into the solution with a little H_2O and the whole kept gently boiling for half an hour on wire gauze over a small flame. After cooling the flask is filled to the mark, well shaken and the precipitate allowed to settle. Than 50 ccm of the clear liquid are taken off for titration, the excess of AgNO_3 being determined with N/10 NaCl solution or N/10 NH_4CNS solution. If the number of ccm of N/10 solution used is multiplied by 5 and the product subtracted from 100 the result is the number of ccm N/10 AgNO_3 solution used by the CHI_3 . The value, multiplied by 0.013119 gives the amount of pure CHI_3 , contained in the quantity of substance examined, from which the percentage strength can be calculated. Good commercial samples should give at least 99.5 % by this method.

Iodoformal. A condensation produce of iodoformin (q. v.) with ethyliodide. It is a heavy yellow powder, insoluble in H_2O , with only a faint smell of iodoform; said to be used as an antiseptic and substitute for iodoform.

Iodoformal:

Dr. C. L. Marquart, chem. Fabrik Beuel a. Rhein (Germany).

Iodoformin = Hexamethylenetetramine iodoform. According to Germ. Pat. 87812 hexamethylenetetramine (q. v.) is rubbed with the requisite amount of iodoform in presence of absolute alcohol.

A whitish powder, turning yellow on exposure to light, with a faint smell of iodoform, M. P. 178°, insoluble in alcohol, ether and chloroform. It is used in surgery as an odourless substitute for jodoform.

Iodoformin:

Dr. C. L. Marquart, chem. Fabrik Beuel a. Rhein (Germany).

Iodolecithine see "LECITHINE".

Iodole = Tetraiodopyrrol. According to Germ. Pat. 35130 it is obtained by treating Pyrrol (a base contained in bone oil and animal oil) with iodic and hydriodic acids.

A light yellow, tasteless, odourless powder, very sparingly soluble in H₂O, easily in alcohol, and still moreso in ether. It is used medicinally, externally as a substitute for iodoform, internally as a substitute for iodides of the alkali metals.

Iodophene see "NOSOPHENE".

Iodopyrine = Iodine antipyrin. Obtained by the action of iodine chloride on antipyrine (q. v.). Colourless crystalline needles, readily soluble in hot, much less so in cold water. It is prescribed as an antipyretic and antineuralgic.

Iodosapene see "SAPENE".

Iodoterpene. An ointment-like substance composed of iodine and terpene hydrate. Said to be a substitute for iodoform.

Iodothyryne. Iodine compound of the thyroid gland. 1 g substance contains 0.3 mg I.

Brownish-white powder, almost odourless, with a taste resembling that of milk-sugar. It is prescribed in goitre, eczema, rachitis, &c. Dose for adults 0.3 g 2 to 6 times a day, for children 0.3 g once to three times a day.

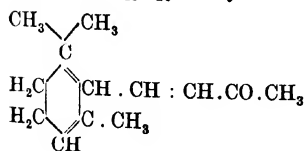
Iodyline = Bismuth iodosalicylate. It is said to be used as a non-irritating, odourless substitute for iodoform.

Iointing material.

Iointing material:

Paul Lechler, Stuttgart, Germany.

Ionone. C₁₃H₂₀. A cyclic ketone of the terpene series. The formula is:—



One of the finest synthetic perfumes (discovered by TIEMANN). It is prepared Germ. Pat. 73089 and 75120 by condensing acetone and citral (q. v.). Equal parts of the two substances are shaken with a solution of Ba(OH)₂ for several days and extracted with ether. The residue after the evaporation of the ether is fractionally distilled under 12 mm pressure. In the fraction coming over between 138° and 155° a ketone, called pseudoionone is present. By treatment with dilute acids it is converted into ionone. The original method has been subjected to many (patented) modifications and improvements. E.g. the condensation may be performed without the addition of alkalies by heating the reagents in autoclaves to 175° (Germ. Pat. 113672). According to Germ. Pat. 147839 the reaction proceeds at the ordinary temperature if sodamide be used as condensing agent.

The crude ionone is a mixture of α -ionone and β -ionone. By treating with conc. H_2SO_4 in the cold a product consisting mainly of the β -compound is obtained, whereas if conc. phosphoric acid or formic acid be used the α -ionone is the chief product. (Germ. Pat. 129027 and 133563.)

Instead of citral itself, cyclocitrals may be condensed with acetone (Germ. Pat. 116637) or homologues or substituted derivatives of acetone may be employed in the preparation of this class of violet perfumes (Germ. Pat. 133758).

By using a cyclocitral which consists entirely or mainly of the α -compound a product is obtained which contains scarcely anything but α -ionone (Germ. Pat. 139959), while a product with a high percentage of β -ionone is obtained by a process protected by Germ. Pat. 138938. This consists in boiling the crude pseudoionone with sodium bisulphite until after distillation in steam, the product of reaction has a S. G. 0.940 to 0.950. The crude ionone so prepared is fractionated under a pressure of 12 mm and the fraction coming over between 125° and 140° collected.

Other patents, including those dealing with the preparation of alkyl derivatives of ionone, must be here omitted.

The ionones have a fine odour of violets. They are sold as 10 % alcoholic solutions.

Iothione. Di-iodohydroxypropane $\text{C}_3\text{H}_5\text{I}_2(\text{OH})$. A yellowish, viscid liquid with a peculiar smell. S. G. (at 15°) 2.4 to 2.5. It contains about 80 % iodine. Almost insoluble in water, readily soluble in alcohol, ether, and fatty oils. When mixed with olive oil, vascline, lanoline, &c. it forms a preparation containing iodine in an easily absorbable state. It is used as a substitute of the alkali iodides (for internal use).

Iridescent glasses see "GLASS COLOURS".

Iridium. Ir. Atomic weight = 193. Heavy metal belonging to the group of platinum metals (q. v.). It occurs in two allotropic modifications, viz. as a compact steel-like substance, S. G. 22.42, which is very brittle when cold, and as iridium sponge S. G. 15.8. With the exception of osmium and ruthenium it is the most difficult metal to melt (M. P. 1950°). When compact it is not even soluble in aqua regia. Iridium alloys, such as platinum iridium and osmium iridium are valuable on account of their unalterable and resistant properties. A mixture of powdered iridium compounds and excess of NH_4Cl when heated yields Ir in a leaf-like state (Amer. Pat. 805316).

Iridium and Preparations:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

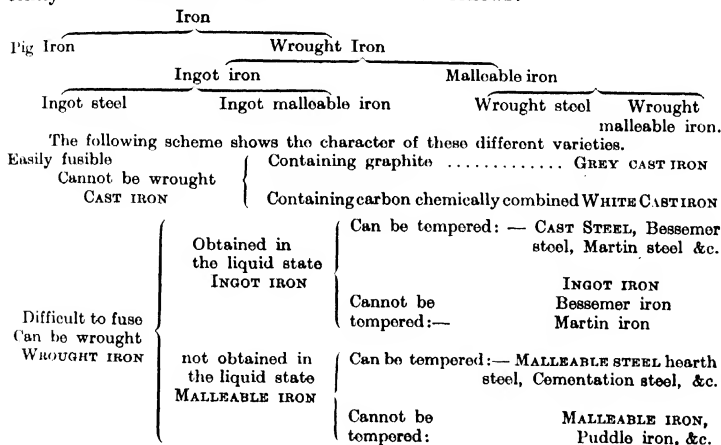
Iridium lamps. Electric lamps in which the filaments are composed of pure Ir. (Germ. Pat. 145456 and 145457).

Iris, Oil of. An ethereal oil of a violet-like odour used in perfumery and soap manufacture. It is obtained from *Rhizoma Iridis florentinae* by distillation in steam. At the ordinary temperature it is a solid mass yellowish-white to yellow in colour, melting at 44 – 50° to a yellow or yellowish-brown liquid. About 85 % of the oil of iris is myristic acid which is quite odourless. The odour of violets is due to irone, a ketone of the formula $\text{C}_{13}\text{H}_{20}\text{O}$. Acid number 213–222. Saponification number 2–6.

Iron. Fe. A. W. = 56.02. Iron is the most important of the heavy metals. It is obtained from red haematite, Fe_2O_3 ; brown haematite $2\text{Fe}_2\text{O}_3, 3\text{H}_2\text{O}$; magnetic iron Fe_3O_4 ; spathic iron FeCO_3 . In addition to these pyrites (FeS_2) is used, but not before the S has been removed by roasting (in the

manufacture of sulphuric acid). From all these ores metallic iron is easily produced by heating with carbon; during the process iron combines with varying amounts of carbon, partly mechanically, partly chemically, and according to the amount contained the properties are modified. The nomenclature of the various kinds of iron is therefore based upon the carbon contents.

Formerly a difference was only made between cast iron and wrought iron, the former containing 2—6 % carbon, the latter 0.02 to 0.5 % C. Between the two comes steel, which can be tempered with 0.6—1.5 % carbon. Recently this classification has been modified as follows:—



(Chemically pure iron is of scarcely any value for technical purposes. Iron must always contain carbon and generally silicon and manganese (phosphorus, sulphur, &c.). Iron with less than 2 % carbon can be wrought and is difficult to melt, with more than 2.8 % carbon it melts easily and cannot be wrought. Wrought iron with less than 0.25 % C cannot be tempered, while iron with 0.25 % C and more can be tempered.

As regards the effects of admixtures on the properties of iron those due to carbon are given above, though in addition the following should be mentioned: While carbon in liquid iron is merely dissolved, in the solid iron we have to distinguish between chemically bound (or better alloyed) carbon and that which is only mixed mechanically with the iron. The latter is in the crystalline state, and is therefore called graphite or graphitic carbon, while the carbon in combination with the iron is called amorphous carbon. If iron saturated with carbon is caused to solidify rapidly by cooling, the product is white cast iron: The carbon has no time to separate, but remains combined with the iron which thus retains its white colour. If on the other hand iron containing much carbon is slowly cooled part of the carbon separates in the graphitic form producing grey iron; the presence of the particles of graphite cause the colour to change from grey to black.

Silicon also plays an important part in iron though less so than carbon. If C is not present in too small quantity Si causes the separation of the C in a graphitic form and in general reduces the total carbon content.

The effect of manganese in iron is almost the reverse of that of Si, in so far as it prevents the separation of graphitic carbon. When Si and Mn are both present in certain proportions the effects due to them may cancel each other.

Phosphorus increases the property of being cast; it renders iron more fusible and less viscid when fused. P must therefore only occur in wrought iron in very small quantities, as otherwise the properties of the latter are changed in an unfavourable manner.

Almost as injurious are the effects of sulphur; it removes the carbon and if present in sufficient amount renders iron useless.

Of other impurities tin may be mentioned; a few tenths percent completely spoils wrought iron.

As remarked above, chemically pure iron is worthless for practical purposes. It is, moreover, scarcely possible to prepare it. Approximately pure iron is obtained by the reduction of ferric oxide, ferrous oxalate and ferrous chloride in a current of hydrogen. When pure it is almost silver-white, shining, hard, tough, and capable of taking a high polish. S. G. 7.84; M. P. of pure iron over 1800° iron expands on heating. See also IRON, INGOT and STEEL.

Iron alloys. As pointed out in the article on Iron all kinds of iron (and steel) alloys used for industrial purposes are compounds of the element with carbon. In the present article the substances regarded as "Iron alloys" proper will be treated.

1. **ALUMINIUM IRON** (Ferro aluminium) and **ALUMINIUM STEEL**. Aluminium iron is either produced directly in electric furnaces by HEROULT'S process (see "ALUMINIUM") or by alloying metallic aluminium with melted iron. Aluminium like Si causes the lowering of the C content of carbon. Ferro-aluminium is very hard and brittle. It is used for refining iron, and also as a permanent ingredient for increasing the strength, hardness and toughness of iron.

2. **CUPRO-STEEL**. Copper has been alloyed with steel up to 4 %. The product may be shaped warm as well as cold and is occasionally used for printing rollers, projectiles, &c.

3. **FERROCHROME** (chrome iron) and **CHROME STEEL**. Ferrochrome is produced by smelting chrome iron ore with carbon and suitable additions. It is added to steel in the crucible process in order to obtain chrome steel. Chromium considerably raises the hardness of steel, so that tools made of chrome-steel are used for working very hard material. In the United States ferrochrome is made directly from the ore in electric furnaces. Ferrochrome contains 62—68 % Cr, rarely more. Chrome steel varies, containing from 2.5 to 5 % Cr and 0.8—2 % C. In consequence of its extreme hardness chrome steel is increasing in importance for the manufacture of projectiles.

4. **FERROMANGANESE** (Manganese iron). Alloy of Fe and Mn with very varying contents of Mn between 30 and 80 %. It is prepared in blast furnaces and is used for purifying ingot iron.

Another method appears to be becoming more important in certain places: According to the Engl. Pat. 17190 (1900) manganese oxide is dissolved in molten fluor spar in electric furnaces and the melt electrolysed while manganese oxides and carbon are added continuously. The electrolysis is carried out at a temperature slightly above the M. P. of ferro-manganese, so that very small losses of fluorine compounds occur through volatilization.

According to Germ. Pat. 147311 a manganese ore containing Mn_2O_3 and Fe_2O_3 is melted with a sulphide of the alkalies or alkaline earths (in presence of C a sulphate may be substituted) and the melt reduced in a hermetically sealed electric furnace, not more carbon being added than is necessary for the reduction of Mn and Fe. The result is ferro-manganese; the oxide of the alkali or alkaline earth metal may be extracted from the melt by hot H_2O .

5. **FERROMOLYBDENUM** and **MOLYBDENUM STEEL**. Ferromolybdenum is produced by reduction of the ore in electric furnaces; Molybdenum steel is

used for large cranks, transmitters, boiler plates &c. The influence of Mo on steel is very similar to that of W, but less Mo is required to give the same results.

Ferro-Molybdenum:

Chemische Fabrik in Fürth G. m. b. H., Fürth, Germany.

6. **FERROSILICON.** An alloy of iron and silicon with but little carbon. It is used like ferromanganese for purifying ingot iron and also in casting works to make iron containing little silicon suitable for casting. According to KROUPA ferrosilicon is made by melting 1000 parts iron scale with 410 parts quartz and 398 parts coke in electric furnaces; the power required is 5000 K. W. hours per ton, and the product contains 77.5 % Fe and 21.5 % Si. In experiments for the manufacture of ferrosilicon from Martin slag (1680 kg) and coke (600 kg) 5380 K. W. hours per ton were required. The ferrosilicon contained 23.8 % Si.

According to the Amer. Pat. 172925 ferrosilicon and silicon spiegeleisen are obtained from Bessemer- and Martin furnace slag, by powdering the slag and heating in electric furnaces with an addition of carbon (in the ratio of 1 mol. C to 1 mol. O). The silicates and oxides are reduced, and metallic silicides formed.

Another new process (Germ. Pat. 143506) has for its object the simultaneous production of ferrosilicon and of the oxides of the alkalis and alkaline earths. Alkali sulphate or alkaline earth sulphate is treated with SiO_2 in such a way that the corresponding silicate is formed. The latter together with a definite amount of carbon, ferric oxide or metallic iron is heated in a hermetically closed electric furnace. The product contains ferrosilicon in addition to alkali oxide or alkaline earth oxide; the latter is obtained as a slag or, if volatile at the temperature of the reaction, as a sublimate.

7. **FERROTITANIUM.** Generally prepared by the aluminothermic method (see "THERMITE") from titanic iron ore. According to GOLDSCHMIDT about 83 to 84 parts aluminium are required to reduce 100 parts iron oxide and 100 parts titanic acid. As the aluminium powder necessary for this process is much more expensive than block aluminium, according to ROSSI an ordinary SIEMENS' electric furnace is used. Aluminium and iron borings are brought into the crucible and when the whole is melted finely-ground titanic iron ore is introduced between electrode and crucible wall. When molten the ferrotitanium alloy is sharply separated from the alumina slag.

Recently, however, ferrotitanium has been produced from the ores by reduction in electric resistance furnaces (without crucible).

8. **FERROVANADIUM and VANADIUM STEEL.** These new alloys have only lately been produced on a large scale. A peculiar property of vanadium steel is that it does not attain its greatest hardness by sudden cooling but by keeping it at 700—800° C for some time (see "VANADIUM").

9. **MANGANESE STEEL.** A small addition of manganese to steel increases its hardness and toughness. Manganese steel is used for wagon wheels, armour plates, &c. If the content of manganese exceeds 2.5 % the hardness increases; beyond 6 %, it decreases while strength and elasticity increase, reaching a maximum with 14 % Mn. More than 20 % manganese has a very deleterious influence on steel.

A special method of preparing manganese steel is protected by the Engl. Pat. 25794 (1903), and a method of rendering manganese steel tough by the Germ. Pat. 155810.

10. **NICKEL IRON (Ferronickel).** An alloy of Fe and Ni, produced by melting together the constituents, used in the manufacture of nickel steel (see below).

11. **NICKEL STEEL.** One of the most important iron alloys, containing as a rule 3—5 % nickel. It is considerably stronger than steel without being less

elastic. In addition, nickel steel is very indifferent to chemical influences. In Europe it is generally prepared by melting iron and nickel together. The product obtained by this method is, however, only satisfactory if the nickel used is exceedingly pure. Nickel steel is used for armour plates, ship's screws, boiler-plates, cable wires, gun barrels, &c.

KRUPP'S armour plate steel contains approximately 3.5 % Ni, 1.5 % Cr, and 0.25 % C.

The Germ. Pat. 154589 protects the preparation of a nickel steel containing tungsten which metal is said to render the material fibrous and to prevent it from becoming crystalline by sudden cooling from a high temperature or by other marked influences.

12. PHOSPHOR STEEL. According to the Germ. Pat. 146205 an alloy containing about 68 % Mn, 25 % P, 5 % C, and 2 % impurities is prepared. Manganese ores containing much phosphorus are melted with C and a flux in a blast furnace, or electric furnace. If insufficient P is present in the ores calcium phosphate, apatite or other phosphorus compounds are added. This alloy when mixed with ingot iron yields phosphorus steel, an alloy which appears to be gaining considerably in industrial importance.

13. TUNGSTEN IRON and TUNGSTEN STEEL. Tungsten iron is obtained by smelting wolframite (iron manganese tungstate) with carbon and iron. At present, however, ferro-tungsten is obtained chiefly by reduction in electric furnaces. The amount of W varies between 70 and 85 %. Tungsten steel is obtained by adding the corresponding amount of tungsten to the steel in the crucible process. The amount of W steel varies between 3 and 25 %, though it generally lies between 5 and 8 %. W affects the properties of steel similarly to Cr, though in a lesser degree. A curious property of tungsten steel is that of hardening of its own accord in the air, without immersion in oil, water, &c. It also retains its hardness and cutting power at very high temperatures. It is an extremely suitable material for magnets, compass needles, &c., as it retains magnetism very effectively and for a long time.

Iron colours see also "MINERAL COLOURS".

1. BERLIN BLUE. The common insoluble Berlin blue is also called Prussian blue, Paris blue, Hamburg blue, Erlangen blue, New blue and Oil blue. Three shades of Berlin blue are generally manufactured, viz. ultramarine, secondly a blue with a deep indigo tone and finally a deep, slightly reddish blue.

Berlin blue is ferric ferrocyanide $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$. It is obtained as a deep blue precipitate by adding a solution of potassium ferrocyanide to a solution of a ferric salt. There must be an excess of ferric salt in order to produce the usual insoluble Berlin blue. According to the shade required the process varies; the precipitation, however, is always carried out at boiling heat. The ferric salt is not precipitated directly, but a solution of ferrous salt (FeSO_4 or Fe_2Cl) iron vitriol or iron chlorine) is used. On adding $\text{K}_4\text{FeC}_6\text{N}_6$ a white precipitate is formed which is converted into Berlin blue by oxidation after being separated from the solution. As oxidizing agents HNO_3 , KClO_3 , or ferric sulphate are used.

Very rarely (e. g. for preparing blue inks) soluble Prussian blue is used. It results when the ferrocyanide is present in excess during the precipitation. If the precipitate obtained under these conditions is washed, it remains insoluble so long as there are any salts adhering to it; as soon as these are completely washed out the precipitate begins to dissolve. Soluble Prussian blue may be obtained from insoluble Prussian blue by treating the latter with concentrated H_2SO_4 , washing, drying, and dissolving in oxalic acid. The following proportions of the ingredients are recommended as effective: 8 parts Prussian blue, 1 part oxalic acid, and 256 parts water.

It should be noticed that commercially pure Berlin blue is called Paris blue, while the lighter shades, obtained by adding white substances (such as plaster of Paris, clay, heavy spar, kaolin, starch, &c.) are called Prussian blue (Berlin blue).

Recently Prussian blue has been produced electrolytically. The method is essentially the same as above described, i. e. a ferrous salt is precipitated with yellow prussiate while the oxidation is effected in the anode compartment of an electrolytic cell. Different shades may be produced by varying the current.

According to the Engl. Pat. 4513 (1903) a saturated solution of potassium ferrocyanide with a small excess of H_2SO_4 is heated with steam under slightly reduced pressure, the residue is boiled with a solution of a suitable ferric salt in presence of free acid and the Berlin blue thus obtained is filtered from the dissolved ferrous salt. The latter can be used for converting a fresh amount of product into Berlin blue (by blowing in air).

Prussian blue is also produced on the fibre. The cotton is prepared with sodium stannate, passed through H_2SO_4 , and then treated alternately with solutions of an iron salt and $\text{K}_4\text{Fe}(\text{CN})_6$.

2. **TURNBULL'S BLUE.** It is obtained by the action of ferricyanide (red prussiate) on a solution of ferrous salt; its constitution is $\text{Fe}_3[\text{Fe}_2(\text{CN})_6]_2$. The ferrous salt must be present in excess if an insoluble blue is desired. Turnbull's blue is considerably dearer than Berlin and Paris blue, on account of the high price of red prussiate.

3. **CAPUT MORTUUM** (Colcothar, English red, angel red, chemical red, Pompeian red, Berlin red, India red, iron minium, &c.). It is the red residue found in the distilling vessels used in the manufacture of fuming sulphuric acid (q. v.). It consists chiefly of iron oxide mixed with basic ferric sulphate. Formerly caput mortuum was only sold as a cheap red paint, but later very fine and high-priced colours of various shades were produced. Crude caput mortuum is heated to redness for several hours in clay pipes with about 6 % common salt and the product allowed to cool gradually in absence of air. By observing certain experimental conditions and various temperatures, all shades between pure iron red and deep violet may be obtained.

According to Germ. Pat. 143517 valuable iron colours are produced by treating substances like nitrobenzene, nitrotoluene, oxy-azo-benzene, nitro- or di-nitrophenols, -cresols and -naphthols, nitroso-phenols, nitroso-cresols or nitroso-naphthols, nitro-naphthalenes, di-nitro-naphthalenes, &c. with an excess of an aqueous solution of ferrous sulphate and cast steel or iron filings and heating. The mixture of basic iron sulphates obtained and the product of reaction is collected in a filter press and heated to $180-250^\circ$ in a closed furnace. As soon as the product is dry, the colours thus obtained are oxidized by heat, iron peroxide is formed as a very fine powder, the colour of which varies from red-brown to dark-brown according to the amount of iron salt used in the reduction. The iron sulphate found in the filtrate can be used again in the process.

According to the Engl. Pat. 16338 (1903) waste liquors containing ferrous salts are oxidized by air and steam, yellow basic iron oxide precipitated and heated to redness so as to produce shades of red Fe_2O_3 . Scarcely different from this is the process of the Amer. Pat. 739444 and 758687.

4. **SIDERINE YELLOW** (Ferric chromate). $\text{Fe}_2(\text{CrO}_4)_3$. It is obtained as an intensely yellow precipitate by adding a perfectly neutral solution of Fe_2Cl_6 to a hot concentrated solution of $\text{K}_2\text{Cr}_2\text{O}_7$. It is used for water colours and oil paints. Mixed with water glass it is used as a paint.

Other iron chromate colours are obtained (Germ. Pat. 140135) by the action of iron compounds on chromates in alkaline solution. Double salts are thus obtained analogous to basic iron alums. By mixing the yellow

shades obtained with other blue shades green colours may be produced *ad libitum*. The Germ. Pat. 146851 protects the manufacture of green colours by mixing yellow iron-chromium colours obtained as above with Paris blue, ultramarine and other blue colours.

Iron compounds.

1. FERRIC ACETATE (see "IRON MORDANTS"). Pure iron acetate is obtained by dissolving freshly precipitated iron hydroxide in 30 % acetic acid. The neutral salt $\text{Fe}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2 \text{H}_2\text{O}$ is easily changed to a basic salt $\text{Fe}(\text{C}_2\text{H}_3\text{O}_2)_4 \cdot (\text{OH})_2$.

2. IRON ALUM. Either potassium ferric sulphate (Potassium-iron-alum); $\text{K}_2\text{Fe}_2(\text{SO}_4)_4 + 24 \text{H}_2\text{O}$ or ammonium ferric sulphate (iron-ammonia-alum) $(\text{NH}_4)_2\text{Fe}_2(\text{SO}_4)_4 + 24 \text{H}_2\text{O}$. It is prepared from green vitriol by mixing an aqueous solution with H_2SO_4 . The solution is then oxidized to ferric sulphate by heat and mixed with a solution of potassium sulphate (or ammonium sulphate) in the proper proportions. The solution is allowed to crystallize when the alum separates in the form of pale violet crystals. It is used in dyeing, medicine, and in chemical analysis.

3. FERROUS BROMIDE see "BROMINE COMPOUNDS".

4. FERROUS CHLORIDE. FeCl_2 . Obtained anhydrous by passing Cl or better still HCl over red hot iron filings. In aqueous solution it is obtained by dissolving Fe in HCl. If the solution obtained is evaporated in absence of air transparent blue-green hygroscopic crystals of the formula $\text{FeCl}_2 + 4 \text{H}_2\text{O}$ are obtained. In re-crystallizing with HCl the salt is obtained with only 2 mol. water of crystallization.

5. FERRIC CHLORIDE. Fe_2Cl_6 . Generally obtained by oxidation of FeCl_2 with HNO_3 or Cl gas, less frequently by passing Cl into water containing iron turnings. The solution obtained by either method is evaporated and crystallized. It crystallizes in various ways either in clusters composed of small radiating yellow deliquescent crystals with $12 \text{H}_2\text{O}$ or in large reddish-brown crystals with $5 \text{H}_2\text{O}$. It is sold either in the former state or as a concentrated solution. It is chiefly used for the chlorination of copper and silver ores, as an oxidizing agent and mordant in the textile industries, for purifying sewage, and in medicine for stopping bleeding.

TEST. The contents of iron chloride solutions are determined by the S. G. (the following tables of FRANZ are used: the temperature assumed throughout is 17.5°C).

S. G.	1.0146	1.0292	1.0439	1.0587	1.0734	1.0894	1.1054
Fe_2Cl_6 %	2	4	6	8	10	12	14
S. G.	1.1215	1.1378	1.1542	1.1746	1.1950	1.2155	1.23656
Fe_2Cl_6 %	16	18	20	22	24	26	28
S. G.	1.2568	1.2778	1.2888	1.3199	13.411	1.3622	1.3870
Fe_2Cl_6 %	30	32	34	36	38	40	42
S. G.	1.4118	1.4367	1.4617	1.4867	1.5153	1.5439	1.5729
Fe_2Cl_6 %	44	46	48	50	52	54	56
S. G.			1.6023	1.6317			
Fe_2Cl_6 %			58	60			

Pure Fe_2Cl_6 should dissolve completely in water. The absence of FeCl_2 is proved by testing with potassium ferricyanide solution which should not give a blue colour. The filtrate from the precipitate obtained with NH_3 by boiling should not be blue (Cu) and should give no precipitate when mixed with ammonium sulphide (Cu, Zn, Mn). Free HCl is recognized by the formation of NH_4Cl fumes when a glass rod moistened with NH_3 is brought near the slightly warmed concentrated solution. Free chlorine as well as nitric acid in the Fe_2Cl_6 solution turns moist zinc iodide-starch paper when it is held

close to the surface of the warmed solution. The Fe contained is determined precisely by titration with stannous chloride solution. If FeCl_2 is also present it is oxidised in a second experiment with KClO_3 , the Cl removed by boiling and the titration repeated. The iron in form of FeCl_2 present is then found by the difference between the two determinations.

6. IRON (FERRIC) CHROMATE, $\text{Fe}_2(\text{CrO}_4)_3$, see "IRON COLOURS" No. 4 Siderin yellow.

7. FERRIC NITRATE. Obtained by mixing metallic iron with heated HNO_3 , S. G. 1.185, evaporating the brown solution obtained and crystallizing. Colourless, hygroscopic crystals, soluble in water giving a brown colour, corresponding according to the concentration of the solution to the formulae $\text{Fe}_2(\text{NO}_3)_6 + 12 \text{H}_2\text{O}$ or $\text{Fe}_2(\text{NO}_3)_6 + 18 \text{H}_2\text{O}$. When the solution is boiled a basic salt separates. Iron nitrate is used as a mordant (see "IRON MORDANTS").

8. FERROUS OXALATE. FeC_2O_4 . Obtained by precipitating ammonium oxalate solution (or a solution of oxalic acid neutralized with NH_3) by a solution of ferrous sulphate. It forms a crystalline lemon-coloured precipitate. It is chiefly used for medical purposes.

9. IRON OXIDES. Ferric oxide, Fe_2O_3 , occurs naturally as red haematite; it is obtained artificially as a red brown powder by heating ferric hydroxide or FeSO_4 in air (caput mortuum); see "IRON COLOURS". Ferric hydroxide, $\text{Fe}_2(\text{OH})_6$, is obtained by precipitating solutions of ferric salts by NH_3 . It appears in red brown flakes which pass into a less hydrated form by boiling in water or drying at a higher temperature; this hydrate is only partly soluble in dilute acids. Freshly precipitated ferric hydroxide dissolves in a solution of ferric chloride with a red brown colour forming ferric oxychloride. If this solution is subjected to dialysis, the residue is a water-soluble ferric hydroxide (Liquor ferri dialysati), a dark red liquid, used as is the oxychloride for medical purposes. — Common rust is also a hydroxide of iron (see "RUST PREVENTIVES").

FERROSFERRIC OXIDE, Fe_3O_4 ($\text{Fe}_2\text{O}_3 + \text{FeO}$), occurs naturally as magnetic iron ore. It is formed when Fe is heated in excess of O and also when CO_2 or steam is passed over red hot Fe. Various patents deal with its production from the iron mordant liquors by neutralizing, oxidizing, and precipitating; it is said to be used as a colour. See also Germ. Pat. 182221.

A still higher form of oxidation is ferric acid which does not occur in the free state. One of its salts is potassium-ferrate K_2FeO_4 .

10. FERRIC SULPHATE. $\text{Fe}_2(\text{SO}_4)_3$. Obtained either by dissolving Fe_2O_3 in H_2SO_4 or according to the method mentioned under "IRON MORDANTS". By boiling the solution basic salts, insoluble in water, are produced. The neutral sulphate is dark brown but when anhydrous is white. It is used as a mordant in dyeing, for disinfection and water purification.

11. FERROUS SULPHATE (Iron vitriol, green vitriol). FeSO_4 . Produced chiefly from iron pyrites by allowing it to oxidize in the air with frequent additions of water. FeSO_4 and free H_2SO_4 are formed and the solution passes into a vessel containing iron filings, &c., which combine with the H_2SO_4 and reduce the ferric sulphate formed to ferrous sulphate. Fe is added to the solution and the whole evaporated, separated from the yellow sediment (basic ferric sulphates and CaSO_4) and then evaporated further until crystallization ensues. It is also obtained as a by-product in the manufacture of alum.

When crystallized with $7 \text{H}_2\text{O}$ it forms bluish-green crystals, while in the anhydrous state it is a white powder. The crystals decompose in the air with oxidation. 100 parts H_2O dissolve 60 parts at 10°C and 333 parts at 100° ; it is insoluble in alcohol. It is used in dye works, in manufacturing ink, Berlin blue, as a disinfectant, &c., &c.

TEST. The amount of Fe is best determined by titration of the dilute solution acidified with H_2SO_4 with KMnO_4 solution. The following table by

GERLACH holds for pure aqueous solutions at 15° C, giving the amount of $\text{FeSO}_4 + 7\text{H}_2\text{O}$ in weights percent.

S. G.	1.005	1.010	1.016	1.021	1.027	1.054	1.082	1.112	1.143
Weigh %	1	2	3	4	5	10	15	20	25
	S. G. 1.174 1.206 1.239								
	Weigh % 30 35 40								

Fe_2O_3 is recognized in solution by adding a little HCl and testing with $\text{K}_4\text{Fe}(\text{CN})_6$ or KCNS solution. The presence of Cu is determined by precipitating the hydrochloric acid solution oxidized by HNO_3 with NH_3 at boiling point. After the $\text{Fe}_2(\text{OH})_6$ is filtered off a bluish colour indicates the presence of copper. Small amounts are more certainly recognized by rendering the ammoniacal filtrate slightly acid with HCl and adding a few drops of $\text{K}_4\text{Fe}(\text{CN})_6$ solution which produces a red brown precipitation or cloud if copper is present. If the green vitriol contains copper a dilute solution of 1—2 g substance is prepared, hydrochloric acid added, H_2S passed through, the whole warmed, the CuS filtered off, the ferrous salt oxidized in the filtrate &c. and the Fe precipitated by adding sodium acetate and boiling; Zn in the filtrate is detected by a white precipitate (ZnS) on passing H_2S through the solution. Should a black precipitate of NiS occur, it should be examined for ZnS. Mn is very frequently present in green vitriol; it is detected by the brown precipitate formed when the filtrate from the basic ferric acetate is heated with caustic soda and bromine water. For many of the uses to which ferrous sulphate is put the presence of aluminium is objectionable. The iron precipitate is treated with hot caustic soda lye (pure NaOH prepared from metallic Na and water) in a platinum dish, the mixture diluted and filtered. The filtrate is neutralized with acetic acid and brought to boiling when $\text{Al}_2(\text{OH})_6$, if present, will be precipitated.

12. IRON SULPHIDES. *Ferrous sulphide*. FeS . Obtained by melting together 3 parts iron filings and 2 parts sulphur in a covered crucible. Yellow-brown crystalline, metallic-looking substance; S. G. 4.7. It is decomposed in the cold by dilute HCl or H_2SO_4 giving off H_2S . It is precipitated from iron salts by alkaline sulphides in a hydrated amorphous form.

IRON SESQUIT-SULPHIDE Fe_2S_3 is formed by gently heating the monosulphide with S, or by the action of H_2S on Fe_2O_3 below 100° C.

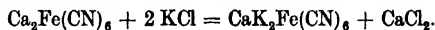
IRON DI-SULPHIDE FeS_2 is found naturally as lustrous brassy-yellow crystals called pyrites. It is a very important mineral and is used in making SO_2 , for the preparation of H_2SO_4 , FeSO_4 &c., &c.

FeS is used in the preparation of H_2S .

13. IRON VITRIOL see No. 11.

14. POTASSIUM FERROCYANIDE (yellow prussiate of potash). $\text{K}_4\text{Fe}(\text{CN})_6$. The following was the old method of manufacture. Potash was melted and dried animal nitrogenous substances (horn, blood, skin, hair, feathers, hoofs, bristles, leather waste, &c.) and iron filings or turnings mixed with the red hot melt. Potassium cyanide KCN and iron potassium sulphide Fe_2S_3 . SK_2 are formed which are converted into potassium ferrocyanide when the cooled melt is extracted with H_2O . The solution obtained is evaporated and the salt purified by re-crystallization.

At present the raw material used is the residue from gas purification which contains ferrocyanogen. The substance is washed free of soluble salts with H_2O and when air-dry intimately mixed with powdered quick lime and heated to 40—100° C in closed stirring vessels fitted with stirring apparatus. Any NH_3 still remaining is distilled off. By extraction with water a strong solution of $\text{Ca}_2\text{Fe}(\text{CN})_6$ is obtained which is evaporated and mixed with the calculated amount of KCl:



The double salt which separates is filtered off, washed and converted into $K_4FeC_6N_6$ by boiling with a solution of potash.

Lastly BUEB's method of utilizing molasses residue may be mentioned. The mass is heated in absence of air until gases are evolved. These are then further heated to the temperature required for the formation of cyanogen; they are then cooled, freed from NH_3 , and the cyanogen absorbed by potash containing iron. When evaporated $K_4Fe(CN)_6$ separates from the solution; a by-product is $(NH_4)_2SO_4$. Other methods will be found under No. 16 "SODIUM FERROCYANIDE".

Lemon coloured non-poisonous crystals, of a bitter-sweet, salty taste containing 3 mol. H_2O . It dissolves in 4 parts cold, in 2 parts boiling water; insoluble in alcohol. It is used in making colours (see "IRON COLOURS"), in explosive works, and in analytical chemistry.

Ferrocyanide of Potassium:

Willy Manger, Dresden, Germany.

15. POTASSIUM FERRICYANIDE (red prussiate of potash). $K_3Fe(CN)_6$. Formerly obtained by passing Cl into a strong aqueous solution of $K_4Fe(CN)_6$, or over the dry substance. It is probably now obtained by electrolytical methods only; by simple electrolysis of a solution of $K_4Fe(CN)_6$ the latter is converted (by the action of the anode oxygen) into ferricyanide. It is obtained in perfectly pure crystals by evaporation of the electrolytical solution.

Dark red crystals crystallizing without water, dissolving in 3 parts water at 4.4° and 1.3 parts water at $100^\circ C$; insoluble in alcohol. It is poisonous. It is used in the colour industry, in dyeing, calico printing, and in analytical chemistry.

16. SODIUM FERROCYANIDE. The process of manufacture is similar to that used in the case of $K_4Fe(CN)_6$, but the following may also be mentioned.

According to the Engl. Pat. 26566 (1902) and 20069 (1903) a ferric salt is precipitated with NH_3 , the slimy precipitate mixed with Na_2CO_3 and the mixture brought into a gas washer into which gases containing cyanogen are passed. The mud is then heated in retorts to remove NH_3 and free ammonium salts, and the sodium cyanide is dissolved in H_2O and separated by filtration from insoluble substances. For further details reference must be made to the patent.

The Germ. Pat. 155806 obtains sodium ferrocyanide from calcium ferrocyanide. A solution of the latter is mixed with NaCl and the resulting sodium ferrocyanide separated from the solution (concentrated if necessary) by crystallization. The process has been previously described by LASSAR-COHN. For modifications see Germ. Pat. 155806 and Suppl. Pat. 169292.

Sodium ferrocyanide crystallizes with 10 H_2O ; it is readily soluble in water and is much used in place of the potassium salt.

Iron Compounds:

Willy Manger, Dresden, Germany.

Iron glazing see "ENAMEL".

Iron leather see "MINERAL TANNING".

Iron mordants. Many iron salts are used as mordants in the textile industries, the most important being the following:

1. IRON ACETATE (Iron liquor, pyrolignite of iron). Obtained as a thick, greenish-black liquor with a tar-like smell by the action of crude pyroligneous acid on iron dust &c. It is used in this form. The tarry substances of the crude pyroligneous acid prevent the ferrous acetate from being oxidized to oxide. It is very largely used in calico printing.

2. **IRON NITRATE.** Obtained by dissolving iron filings, turnings, &c. in HNO_3 . Not very frequently used. It is used in cotton dyeing to produce rust colours.

3. **FERROUS SULPHATE** (Copperas, green vitriol). For its preparation see "IRON COMPOUNDS". It is chiefly used in dyeing blacks on wool.

4. **FERRIC SULPHATE.** Obtained by the oxidation of FeSO_4 solution — mixed with H_2SO_4 — by means of HNO_3 ; according to the amount of H_2SO_4 added neutral or basic salts are formed. It is used for dyeing black on cotton.

Iron varnishes (lacs) see "ASPHALT LACS".

Iron, elimination of. Water containing iron must have this impurity removed for domestic and various industrial purposes.

To do this the water is well oxidized e. g. by letting it trickle over heaps of coke through towers filled with plates, &c. The iron dissolved as bi-carbonate is then converted into insoluble FeCO_3 or $\text{Fe}_2(\text{OH})_6$. After this simple filtration is all that is necessary.

Further details will be found in the article on "WATER PURIFICATION AND FILTERING".

Iron, ingot. Ingot iron is malleable iron prepared in the liquid form, (see "IRON" and "WELDING") while wrought iron is prepared in the non-liquid form.

Ingot iron (which includes ingot steel and ingot malleable iron) may be produced 1. by simply melting steel or wrought iron, 2. by melting a mixture of cast iron and wrought iron, and 3. by melting and oxidizing cast iron.

As these three methods of production are, in practice, not sharply marked off from one another the manufacture of ingot iron is better considered under three headings:— CRUCIBLE PROCESS, HEARTH FURNACE PROCESS, and CONVERTER PROCESS.

a) CRUCIBLE PROCESSES.

Steel is remelted in crucibles, the air being carefully excluded. When the percentage of carbon is to be altered, either very pure raw iron or very pure ingot iron may be added. Charcoal is added, or sometimes graphite crucibles are used, in which case carbon is taken up from the crucible itself. Fire clay crucibles are also used. When a high degree of hardness is required, manganese, chromium, nickel, &c. are added. Ferromanganese is used for deoxidizing ferrosilicon and for removing gases. Pyrolusite, lime, glass powder and crucible fragments are added to assist the formation of slag. The process is seldom carried out with coke-firing as gas furnaces are generally used.

Crucible ingot steel, when the process is properly conducted, is of excellent quality; the cost of production is, however, high, so that this process is only employed when the articles for which it is to be used, will bear high prices (hard steel tools, gun barrels, armour plates, &c.).

Those methods employing electric steel-furnaces on the induction principle, e. g. KJELLIN's furnace, may be described as crucible process. (See "STEEL".)

b) OPEN HEARTH PROCESSES.

The principle of the method is that a mixture of different kinds of iron containing varying amounts of carbon (cast iron and wrought iron) are melted together. The percentage of C can thus be varied within wide limits. As, however, the process is carried out in large reverberatory furnaces, a partial refining, due to the melting and oxidizing takes place, i. e. the amount of carbon is diminished. See WROUGHT IRON. This so-called MARTIN process has spread very considerably since the invention of SIEMENS' method of heating by gas

and is therefore as generally carried out usually called the **SIEMENS-MARTIN** process.

The **MARTIN** furnace is reverberatory, in shape like a basin, made of iron plates covered with clay and lined with fireproof sand. Since this lining (fettling) is rich in silica it is impossible for the phosphorus to be removed in the slag, and its presence in the iron is objectionable. For this reason the process was limited to the case of iron ores poor in phosphorus and it only became generally applicable when **S. G. THOMAS** in 1878 introduced a basic lining of lime and magnesia.

A mixture of cast iron and scrap wrought iron is used with additions of ferromanganese, ferrosilicon, spiegeleisen, and (in the basic process) limestone or quick lime are also added to form slags, i. e. to combine with the phosphoric acid.

A disadvantage of the **MARTIN** process compared with the converter process mentioned below, is that it can not be conducted, like the latter, without the expenditure of fuel; on the contrary, very considerable quantities of gaseous fuel are required. On the other hand not all kinds of ores can be used in the converter process, and continuous working is out of the question. Further the **MARTIN** process is dependent on the scrap-iron market as it can only be carried on where there is a sufficient supply of scrap.

In order to enable the **MARTIN** process to compete with the converter process the former has been subjected to various alterations, with a view 1. of rendering it independent of scrap-iron, and 2. to make the work continuous.

As has been stated the original **MARTIN** process consisted of melting together cast-iron and wrought iron so as to obtain a metal with a moderate percentage of carbon; later the aim was to remove all carbon and phosphorus in **MARTIN** furnaces and to re-introduce the requisite amount of carbon afterwards.

The more important the **MARTIN** process became the more difficult it became to obtain the necessary quantities of wrought iron in the form of scrap. Consequently the actual **MARTIN** process has gradually been replaced by a modification due to **WILHELM SIEMENS**. **SIEMENS'** method is to add to the molten iron the oxygen necessary for oxidizing the impurities in the form of iron ores (as pure as possible).

These so-called indirect methods, in which oxidation of the raw material is due to the oxygen present in the ores, differ radically from the direct methods, in which the cast iron is directly oxidized by atmospheric air.

The **DUPLEX** process is one of the most important direct methods. The cast iron is placed in a Bessemer converter (see below, under c), refined by oxidation and the product then removed to the **MARTIN** furnace where it is finished.

A second process of the kind is that known as the **DAELEN-PSCHOLKA** process. Here the "blowing" does not take place in converters but in circular pans placed close to furnace. Air is blown into the molten cast iron, and the further treatment carried out in the **MARTIN** furnace.

A third direct method is that of **KERNSHAW**. The iron on leaving the furnace runs down an inclined gutter, air being forced into the molten substance during its passage. The iron thus refined is in this case also further treated in the **MARTIN** furnaces.

In the indirect methods generally known as the ore processes, preliminary refining cannot be attained without fuel, since the oxygen of the ore can only be made available at the expense of considerable quantities of heat.

For the ore process, too, various modifications have been introduced, e. g. in the so-called **MONELL** process lime and iron ores are heated in **MARTIN** furnaces and molten cast iron then introduced. Particularly important, however, are the continuous reverberatory processes in which the oxidation is effected by the addition of ores. There are three types of this.

In the **BERTRAND-THIEL** process, two reverberatory furnaces are used. In the first only a little ore is added to the cast iron, not quite enough to remove impurities; cast iron thus remains in excess. The metal is then drawn into the second furnace where it acts on fresh ore, and here complete purification and reduction take place.

The second process of this kind is that due to **TALBOT** in which a tilt furnace is used. First scrap iron is melted, ore and lime (to remove the phosphorus) added, and then liquid cast iron introduced. The whole is then heated, the slag taken off by tilting and finally $\frac{1}{3}$ of the contents is tilted into pans where the reducing and re-carbonising are effected by adding ferromanganese and anthracite. The part tilted out is replaced by corresponding amounts of ore and cast iron which is melted, and again tilted out &c., &c. **TALBOT** furnaces need to be emptied completely only once a week.

The third method is the **HAENTKE** process. It is very similar to the **TALBOT** process, but works with a fixed furnace. There are three outlets in the side of the furnace at different heights so that the slag, or that part of the iron which is to be refined can be let out, or thirdly (through the lowest opening) the whole furnace can be emptied.

c) CONVERTER PROCESSES.

These methods of producing ingot iron are based on oxidation by atmospheric air. Air is forced through the liquid cast iron containing carbon, and malleable iron is produced. The amount of heat developed in this process (which is exceedingly rapid) is so large that the product remains liquid without further heating. This **BESSEMER** process, named after its inventor, is carried out in large pear-shaped vessels. The converter with an opening at the top, is mounted on trunnions so that the contents can be poured out by tilting. The capacity of the converter is from 8 to 18 tons. The bottom is fitted with a number of openings through which the air is forced. Originally the **BESSEMER** process was only suitable for ores containing little phosphorus, but the introduction of **S. G. THOMAS'** basic lining rendered possible the use of raw material containing more phosphorus. This modification is known as the **THOMAS** process. 10 tons iron require 15—25 minutes "blowing" in the converter: The molten iron is allowed to run into the converter (in the **THOMAS** process limestone is first added to form a slag with the phosphoric acid), air is blown through and the converter righted. The spectrum of the flame at the mouth of the converter indicates the end of the process, the converter is then tilted and the iron runs into the casting pan. It should be noticed that **BESSEMER** works on a small scale are now becoming of greater importance: the converters used contain about 750 kg iron. The result is that small quantities of steel which as a rule were formerly made in **MARTIN** furnaces can now be made much more cheaply, the initial costs being in the proportion of 1 : 4. As this industry is not based on the production of large quantities but may be adapted to the size of casting required, and as "temper" iron and fine iron can also be cast with converters, a favourable future may be prophesied.

The only difficulty in the converter process is the removal of just the right amount of C. Generally the whole of the carbon is first oxidized and the pure iron recarbonized by the addition of spiegeleisen in the acid process (**BESSEMER** process), and coke in the basic process (**THOMAS** process). In the latter case the carbon is not allowed to act before the material reaches the casting pan (i. e. after removal of slag).

The Germ. Pat. 159355 protects a process which is an adaptation of the **TALBOT** process mentioned above under b) on the lines of the **BESSEMER** process. The contents of the converter are converted into steel, half of it is poured into a pan while the residue with most of the slag remains behind in the

converter. Molten cast iron, from the blast furnace is now introduced and the slag at once reacts with the impurities of the cast iron. The converter is then tilted and part of the slag emptied out. If the cast iron contains phosphorus fresh lime is added and blowing commenced. When cast iron containing no phosphorus is used the addition of lime is unnecessary. Finally the converter is tilted, part of the steel is poured off, the remainder of the slag enriched by oxide of iron and a fresh amount of cast iron added and the process continued.

It is a mistake to assume that any cast iron containing phosphorus can be treated by the THOMAS process; on the contrary the contents of P must be very high (in direct contract to the acid process); P is necessary as a heat-developer, since otherwise the temperature will not remain high enough to keep the iron molten in the converter. On the other hand the silicon contained should be low in the THOMAS process, as otherwise the basic lining of the converter is rapidly destroyed. In the actual BESSEMER process in which raw material containing little P is used, the Si acts as the heat developer.

The results of the BESSEMER- and THOMAS processes are exceedingly variable, varying according to the raw material and the method of working and ranging from the softest ingot iron to hard steel, though the soft product as a rule is formed. The slag from the THOMAS process is used as manure when ground (Thomas phosphate); see "MANURES, ARTIFICIAL".

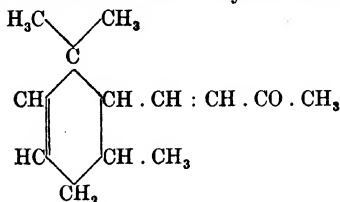
d) DIRECT PRODUCTION OF INGOT IRON FROM ORE.

See the article on "STEEL", where the methods of production of ingot iron in electric furnaces is treated.

The Germ. Pat. 146204 treats of the purification of liquid iron. Molten iron in thin strata is dropped over cones and funnels and brought into close contact with the air.

According to the Germ. Pat. 147313 acetylene is used for carbonising liquid iron. This method is not unknown, but it has the drawback that solid carbon separates in the pipes. The new invention purposes to remove this objection by mixing acetylene with an indifferent gas (for instance CO). The acetylene gas mixture is allowed to enter through spouts into a BESSEMER converter or is conducted into the fused contents of a MARTIN furnace.

Ironone. Whilst ionone (q. v.) is a synthetic product with an odour resembling that of violets to an extraordinary extent, the isomeric ironone must be regarded as the odoriferous constituent of the violet root. (It is possible that ionone is also present.) The constitution is shown by the formula



It is obtained from oil of iris by saponifying the alcoholic solution with potash, extracting with ether, distilling off the ether, and collecting the fraction which passes over first. By treating with phenylhydrazine, the ironone is obtained free from the impurities which at first accompany it.

Isarol. A compound resembling ichthyol obtained from it by treatment with conc. H_2SO_4 . It dissolves in water forming a clear solution. Its use is similar to that of ichthyol (q. v.).

Isatine see "INDIGO DYESTUFFS".

Isinglass see "GLUE".

Isn. A liquid preparation of iron with 0.2% ferrous saccharate. It is in reality a mixture of ferrous citrate (containing oxide) and sugar.

Isoeugenol see "EUGENOL".

Isoform. p-iodoanisol $\text{C}_6\text{H}_4 \begin{smallmatrix} \nearrow \text{OCH}_3 \\ \searrow \text{IO}_2 \end{smallmatrix}$

Obtained by the oxidation of iodoanisol. Used as a mixture with calcium phosphate.

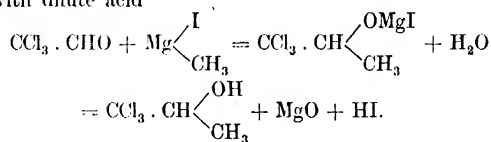
White voluminous, crystalline powder with a silvery lustre and a faint smell of aniseed. Insoluble in alcohol and ether, sparingly soluble in cold, more readily in hot H_2O .

It is chiefly used as an antiseptic for external use as a substitute for the disagreeably smelling iodoform. Internally it is given in quantities of 0.5 g one to four times a day as an antiseptic.

Isol. An oil forming a permanent emulsion with hot or cold water. Used in oiling textiles. It is economical and forms no objectionable lime soaps with hard water.

Isopral. Trichlorisopropylalcohol. $\text{CCl}_3 - \text{CH} \begin{smallmatrix} \nearrow \text{OH} \\ \searrow \text{CH}_3 \end{smallmatrix}$

Prepared by treating chloral with magnesiummethyl iodide and decomposing the product with dilute acid



It forms colourless prisms, M. P. 49° . Soluble in alcohol and ether, with difficulty in H_2O . Recommended as an hypnotic (it is twice as powerful as chloralhydrate). Dose 0.5—1 g or in cases of insanity 2—3 g.

Isosafrol. $\text{C}_6\text{H}_3 \begin{smallmatrix} \nearrow \text{CH} : \text{CH} \cdot \text{CH}_3 \\ \searrow \text{O} \nearrow \text{O} \searrow \text{O} \end{smallmatrix} \text{CH}_2$ (1) (3). Isomeric with safrol (q. v.), and (4)

easily formed from it by long continued heating with sodium or potassium ethylate. A liquid, B. P. $246\text{--}248^\circ$, with a strong smell of aniseed. It is used in perfuming soap and also, because of the ease with which it can be oxidized, in the preparation of piperonal (q. v.).

Isso soap. A solid sulphonic derivative of castor oil. It is neutral, completely soluble in hot water giving a clear solution, and even with the hardest water forms no lime soaps. It is used for bleaching, washing, dressing, &c. in the textile industries.

Isso soap (solid new sulphoderivate of castor oil):

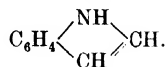
Louis Blumer, Zwickau Sa., Germany.

Itrol. Silver citrate. $C_6H_5O_7Ag_3$. Obtained as a white precipitate by adding $AgNO_3$ to sodium citrate. Used as an antiseptic in the treatment of wounds, inflammations, &c.

J

Japan Lac. The thickened juice of the Japanese plant *Rhus vernicifera*. It is remarkable for its lustre and durability, is insoluble in all acids and solutions generally. Specimens of 11th and 12th century work are still remarkable for lustre, &c.

Jasmine. Of the many remarkable syntheses of perfumes the preparation of jasmine stands high. It has been found that the characteristic smell of jasmine may be obtained by acting upon jasmone with indol. Jasmone is a ketone with an exceedingly strong odour. Indol which is formed during the putrefaction of proteid-like substances can be prepared synthetically:—
 o -nitrotoluene \rightarrow o -nitrobenzylchloride, \rightarrow o -nitrostilbene, \rightarrow o -amido-
 stilbene \rightarrow , indol



The preparation of indol for this purpose is protected by Germ. Pat. 139822, that of jasmone by Germ. Pat. 119890. For the preparation of synthetic jasmine the following formula is given:— benzylacetate 27.5, jasmone 1.5, linalylacetate 11, linalool 2.5, methyl ester of anthranilic acid 0.1, benzyl alcohol 11.65 parts are mixed and treated with 1.25 parts indol. A cheaper and almost equally good preparation can be obtained (Germ. Pat. 132425) by mixing benzylacetate 55, linalyl acetate 15, linalool 10, and benzyl alcohol 20 parts.

Jatrevine. A condensation product of menthol camphor and isobutyl phenol. It is a clear colourless liquid with a peppermint-like smell. Recommended as an inhalation in cases of acute and chronic catarrh.

Jaune brillant see „CADMIUM COLOURS“.

Juniper oil. An essential oil obtained from the berries (fruit) of *Juniperus communis* by distillation with water. It is at first a colourless, later greenish or brownish-yellow liquid. S. G. (at 15°) 0.865 to 0.885; B. P. 171—181°. It has a strong characteristic smell and a spice-like taste. Cadinene and pinene are two of the constituents. The oil, which is soluble in alcohol and ether, is used in medicine, but principally in the manufacture of liqueurs. From the wood of the Juniper tree an empyreumatic oil (Ol. cadini) is obtained.

Jute. The bast fibres of various species of *Corchorus* native to East India and China and now grown in America. The plants are steeped in water and the bast stripped away. The fibres are 1.5 to 2 m long and 0.01 to 0.03 mm broad. To increase the flexibility the jute is often saturated with oil or blubber (hence the offensive smell frequently noticed). It is worked up into sacking, sail cloth, window blinds, &c. It is not well adapted for rope-making since it is not very strong and easily rots in the damp.

Jute dyeing. Although a vegetable fibre, jute behaves in a manner very different from cotton and linen. Basic dyestuffs dye jute without previous mordanting; substantive dyestuffs dye it in a soap-bath and acid colours after mordanting with aluminium mordants.

K

Kainite see „ABRAUM SALTS“.

Kaolin (China clay). A pure clay used in the preparation of glass, fireproof articles, &c.

Kermes. The dried females of *Coccus ilicis* occurring in the form of brownish, red pieces of the size of a pea. It contains a dyestuff allied to carmine and is used only in Turkey for dyeing Fez.

Ketones. A class of organic compounds allied to the aldehydes. Like the latter the ketones contain the carbonyl group CO; in the aldehydes there is only one while in the ketones there are two alkyl groups. The simplest ketone is dimethylketone $\text{CH}_3 \cdot \text{CO} \cdot \text{CH}_3$ commonly known as acetone (q. v.). Ketones in which the O is replaced by the NH group are called ketonimides.

BENZOPHENONE. $\text{C}_6\text{H}_5 \cdot \text{CO} \cdot \text{C}_6\text{H}_5$. Obtained by the dry distillation of calcium benzoate. The distillate is fractionated and the portion distilling between 190° and 210° which soon solidifies is drained and recrystallized from alcohol. It may also be obtained by the action of COCl_2 on benzene in presence of Al_2Cl_6 .

Large rhombic crystals, M. P. 48.5° ; B. P. 305° ; insoluble in water, readily soluble in alcohol and ether. It is used in the preparation of other compounds, more particularly coal-tar colours.

ACETOPHENONE. $\text{C}_6\text{H}_5 \cdot \text{CO} \cdot \text{CH}_3$. Used under the name of hypnone (q. v.) as a soporific.

Kieselgur see „INFUSORIAL EARTH“.

Kino. Bark extracts of various kinds similar to catechu (q. v.) used in dyeing and tanning. Amboina kino, Malabar kino and Pterocarpus kino are the most important varieties. It is slightly soluble in cold water, more readily in hot water and in alcohol. From the hot aqueous solution a gelatinous mass separates on cooling. Kino occurs in angular, shining, dark brownish-red lumps.

Kolanine. A glucoside found in the kola nut which is decomposed by enzymes into caffeine, kola red and sugar.

When chewed it is decomposed into its constituents. It is ordered as a stimulant in many diseases, particularly in cases of exhaustion and heart weakness, in neurasthenia. It is used in the form of tincture, pills, pastilles, &c. prepared from kolanine extract, 1 part kolanine is equal in activity to 14 parts of the fresh drug.

L

Laboratory apparatus.

Laboratory apparatus. Refractometers, Heating microscopes:

Optical analysis according to Prof. Haber: Prosp. Carl Zeiss, Jena (Germany).

Contractors for Laboratory Equipment:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Laboratory equipment. Mikro Catalogue M 184, Page 108:

Optical analysis according to Prof. Haber: Prosp. Carl Zeiss, Jena (Germany).

Lacs.

Chemicals for preparation Lacs:

Dr. Hoehn & Co., Neuß a. Rhein, Germany.

Lac-dye. (LACK-LACK.) A colouring matter obtained from *Coccus lacca* (*Coccus ficus*). The animals live on the branches of various East Indian species of *Ficus*. Their stings pierce the tree and the exuding latex with the animal is dried forming a dark red resinous mass. The twigs yield STICK-LAC (10 % colouring matter). The resin deprived of a portion of the dyestuff is called SEEDLAC (2.5 % colouring matter).

The red dyestuff, obtained by extracting the resin with water, is used principally for dyeing wool, mordanted with aluminium salts. The colouring matter is dissolved in HCl. The resin after the extraction of the colouring matter is shellac (q. v.).

Lacquers. The best known natural lac is the STICKLAC (see above) and also SHELLAC.

Japan lacquer is a direct plant product. In order to obtain it, horizontal incisions are made in the bark of the lac tree (*Rhus vernicifera*) and the lac scraped off. The crude substance is a greyish-white viscid emulsion which is purified by pressing through cloth, filtering or treating with aqueous solutions. Japan lacquer is valuable on account of its extraordinary resistance to heat, acids and alcohol.

The so-called China lacquer is an artificial product obtained by dissolving mastic, sandarac and "gurjun" in alcohol.

The lacquers used in Europe are usually artificial products (see „VARNISHES“). The lacquers mentioned here are those made with oils (see „LINSEED OIL VARNISH“) and are prepared by dissolving resins in drying oils. The resin most largely used for this purpose is copal (q. v.). It is first melted in copper or earthenware vessels over a free fire or preferably by superheated steam. The copal is heated to about 350° until about 25 % has distilled over (copal oil). It is often, however, merely heated to a much lower temperature, and the previously warmed solvent added. Pure linseed oil is rarely used, its place being taken by linseed oil varnish (q. v.). Amber is often added partly to replace copal. The lacquer is filtered through cotton or in specially constructed filters. Frequently turpentine is added; the product then somewhat resembles the liquid varnishes.

The cheap resin oil varnishes are solutions of copal, amber, and colophony in resin oils (q. v.).

The following are selected from the large number of recent patents:—

According to Germ. Pat. 143777 wood-tar is neutralized with Na_2CO_3 washed with water, evaporated, boiled with common resin and the mixture dissolved in turpentine, petroleum ether or essential oils. The product is a quickly-drying, waterproof lacquer.

According to Germ. Pat. 154219 excess of resin oil is mixed with non-drying oils and pitch and heated until a uniform mass is obtained. A slight modification of the process is found in Suppl. Germ. Pat. 155107.

Lacquers may be obtained (Germ. Pat. 145388) from fossil resins by the addition of palmitic acid to the crude melt. The coarsely-ground resin (copal, amber, &c.) is heated with the palmitic acid until a clear homogeneous mass is formed and afterwards heated with drying oils, essential oils, &c. as above. Spermaceti and palm oil are mentioned as suitable sources of palmitic acid. Further it may be mentioned that certain constituents of coal-tar (coumarone, indenenes, &c.) which readily polymerize have been used in the lacquer industry.

Lactarine = purified caseine.

Lactarine paper see "PHOTOGRAPHIC PAPERS".

Lactic acid. $C_3H_5O_3$. The usual acid obtained by the lactic acid fermentation of milk is α -oxypropionic acid (ethylidene lactic acid), $CH_3 \cdot CH(OH) \cdot COOH$. On a commercial scale it is prepared as follows:— 3 kg. cane sugar and 15 g tartaric acid are dissolved in 17 litres of boiling water. The cane sugar is thus converted into dextrose and laevulose and then 4 litres sour milk and 100 g ripe cheese are stirred into the mixture. To combine with the acid 1.5 kg $ZnCO_3$ are added. After standing for eight days the zinc lactate which separates as a crust is removed, recrystallized and decomposed with H_2S . After filtering off the ZnS the filtrate is concentrated to a syrup, extracted with ether to remove mannite and any unchanged zinc salt, and the ethereal solution again concentrated to a syrup.

On a large scale the acid may be prepared by the process of LARRIEU (French Pat. 206506). Starch and starchy substances are fermented in presence of NH_4NO_3 . 900 kg starch are mixed with 100 kg malt at a temperature of 50° . The mixture is warmed to 75° until the starch forms a thick paste which is then removed to a fermenting vessel and 0.5 kg NH_4NO_3 added. The fermentation takes place at 50 – 65° and is allowed to proceed for 20–30 days. One half of the acid is then neutralized with Na_2CO_3 , filtered and evaporated until the S. G. is 1.21. 500 kg $CaCO_3$ are added, the calcium lactate decomposed with H_2SO_4 , the $CaSO_4$ removed by filtration and the solution evaporated to a syrup.

The method of JACQUEMIN deserves mention. It is as follows:— Diastatic fermentation of malt is allowed to proceed as in brewing, but the mashing is allowed to continue for a longer time at 50° . The object of this is to increase the amount of maltose and to decrease the amount of dextrine to as great an extent as possible. The temperature is then gradually raised to 60 – 65° , and finally to the boiling point in order to destroy all ferments. The wort is then allowed to cool to 45° , treated with a carbonate, and a pure culture of the lactic acid bacteria added. The fermentation proceeds for 5–6 days at 40 – 45° ; the liquid is filtered and evaporated. The calcium lactate which crystallizes out is treated in the usual way.

Pure lactic acid is obtained (Germ. Pat. 140319) by extracting the aqueous solution of the crude acid with amyl alcohol in which the usual impurities, such as sugar, gums and mineral substances, are insoluble. The upper alcoholic layer is removed and the residue treated with fresh alcohol. In order to obtain an aqueous solution of lactic acid the alcoholic solution is extracted with water or distilled in steam.

Crude lactic acid may be purified (Germ. Pat. 169992) by mixing with equivalent amounts of aniline, cooling the mixture, recrystallizing the salt and decomposing with steam.

Pure lactic acid is obtained (Germ. Pat. 171835) by treating the crude lactates with equivalent amounts of alcohols and warming with a mineral acid. From the ester so obtained the alcohol is recovered and the lactic acid separated.

Lactic acid is a syrup soluble in water, alcohol and ether which can only be obtained in the dry state with difficulty. When chemically pure it forms a crystalline mass M. P. 18° .

TEST. For the quantitative estimation of lactic acid in the commercial product 10 g acid are made up to 100 ccm and titrated hot with $N/1$ KOH (phenol phthaleine as indicator). 1 cc $N/1$ KOH corresponds to 0.0906 lactic acid.

Lactic acid may be recognized by the following test:—

3 ccm acid are warmed with 10 ccm of $KMnO_4$ solution (1 : 1000) when the characteristic smell of aldehyde will be observed.

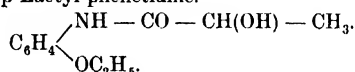
A 10 % solution of sarcolactic acid is rendered cloudy by the addition of a solution of CuSO_4 .

Lactic acid:

W. & C. Plantin, 147 Upper Thames St., London E.C.

Lactoleum. A kind of liquid linoleum (q. v.). The ingredients — cork powder and cement — are mixed cold at the place where they are to be used and laid on the floors. In 3—4 days the substance has become hard enough to be walked upon. Lactoleum can be made in all colours and is said to be more elastic than linoleum.

Lactophenine = p-Lactyl phenetidine.



Obtained by the action of lactic acid on p-phenetidine.

Colourless and odourless crystals with a slightly bitter taste, of M. P. 117 to 118°; sparingly soluble in cold, more readily in hot H_2O , easily in alcohol. It is given as an antipyretic, especially in cases of typhoid, and as an analgetic in neuralgia, rheumatism, &c.

Lactose see „MILK SUGAR“.

Lactoserve see „MILK PREPARATIONS.“

Laevulose see „FRUIT SUGAR“.

Lakes. Mixtures or chemical compounds of dyestuffs with colourless mineral substances that can be easily reduced to powder. They are obtained by precipitating organic dyestuffs with gypsum, heavy spar, aluminium hydroxide, tin hydroxide, clay (burnt or unburnt), &c. All kinds of dyestuffs, vegetable, animal and synthetic, are used in the manufacture of lakes. In the case of coal-tar colours, starch is used as a binding agent. By choosing different substances to take up the dyestuff lakes of various shades may be obtained.

Lakes only exhibit their lustre in thin layers. They are used as oil- and water-colours, but are not very permanent.

They may be obtained (French Pat. 336433) from azo dyestuffs or from sulphur dyestuffs (Germ. Pat. 150765).

Lampblack see „SOOT“.

Lanoline see „WOOL FAT“.

Lanthanum and Lanthanum compounds. Lanthanum, La, A. W. 138.3, belongs to the group of rare metals. It is found in gadolinite, cerite, orthite, and monazite. The metal itself is not of importance but the oxide La_2O_3 and the corresponding salts are now prepared from monazite on a commercial scale for the manufacture of incandescent mantles. The carbonate, $\text{La}_2(\text{CO}_3)_3 \cdot 3 \text{H}_2\text{O}$, the nitrate $\text{La}(\text{NO}_3)_3 \cdot 6 \text{H}_2\text{O}$, the sulphate $\text{La}_2(\text{SO}_4)_3 \cdot 9 \text{H}_2\text{O}$ and the double sulphate of lanthanum and potassium $\text{La}_2(\text{SO}_4)_3 \cdot 3 \text{K}_2\text{SO}_4$ are used for this purpose.

Lard. Obtained either by melting hog's fat over an open fire, or in water, or by steam. It is a pure white substance consisting chiefly of oleine, palmitine and stearine with about 0.25% unsaponifiable substance. S. G. (at 15°C)

0.930 — 0.940; S. G. at 100° C is 0.861. M. P. varies between 28° and 42°. At a temperature of 42° lard is still cloudy and does not become clear below 48—50°. It is soluble in ether, chloroform, carbon disulphide, hot benzene, also in 27 parts boiling alcohol. In the presence of light and air it quickly becomes rancid.

Many methods of purifying impure lard have been proposed. CaCl_2 is used (Germ. Pat. 105671). MgO and MgCO_3 are said to be also used. E. MEISSL proposes to bleach brown strong-smelling lard by stirring in 0.25—0.5 % of the residues from the manufacture of $\text{K}_4\text{Fe}(\text{CN})_6$ (carbon containing iron oxide and silica) at 80° C and then forcing through filter presses.

In addition to its use in cooking it is employed for making ointments, toilet soaps, and for oiling leather. The solid residue left after pressing out the lard oil (q. v.), (Solar-stearin) used for making candles.

Lard oil. Various products are known under this name, e. g. the oleine of lard, separated from the latter by pressing (the solid residue is palmitine and stearine). It is also called bacon oil, and is used to make soaps, pomades and lubricants.

A clear golden oil obtained from rape seed oil by treatment with lyes and superheated steam is known as lard oil. It is an excellent lubricant.

Lavender, oil of. The essential oil obtained by distillation with water from the flowers (or the whole plant in some cases) of *Lavandula officinalis* (*L. vera*). The finest kinds are prepared in England from cultivated plants. It is a colourless or faintly yellow essential oil with a pleasant odour and a burning spice-like taste. S. G. (at 15°) 0.880 to 0.890; B. P. 186—192° (α)_D = — 4° to 9°. The chief constituents are linalool, linalyl acetate, geraniol, and cineol. In presence of air and light it readily resinifies. It is used for toilet purposes and also as an addition to surgical dressings.

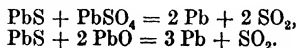
Of considerably less value is spike oil S. G. 0.851 to 0.881, obtained from *Lavandula spica*. It is used as a medium for colours employed in glass and porcelain painting, in making varnishes, in surgical dressings and as an adulterant of the true lavender oil.

Laxatol. An aperient medicine. The principal active constituent is phenolphthalein.

Laxin. An aperient preparation containing 1.87 % malic acid and 5.92 % phenolphthalein.

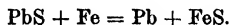
Lead. Pb. A. W. 206.9. The principal ore is galena from which the metal is obtained by one of four methods.

1. **ROASTING PROCESS.** It is carried out in hearth or reverberatory furnaces and depends upon the action of the product of roasting on the undecomposed galena (PbS). During roasting PbSO_4 and PbO are formed which act upon the unchanged PbS thus:—



The roasting method is only suitable for pure ores. They must be free from SiO_2 , otherwise large quantities of lead are retained in the slag.

2. **PRECIPITATION.** This is conducted in shaft furnaces; The ores are melted in the crude state while some substance such as iron is added to take up the S from the PbS :



The iron is not added in the metallic state but in the form of ores which are reduced in the furnace itself. Such additions containing iron are iron stone, iron slags, &c.

This method in spite of its theoretical simplicity is becoming obsolete, as the proper working of the process requires a very high temperature, otherwise much Pb is taken up by the FeS. Impure ores cannot be treated by this method, but it may be applied with advantage when the raw material contains much silica.

3. ROASTING and REDUCTION. This process is conducted in blast furnaces. It is the most usual process of obtaining lead and is suitable for all kinds of lead ores, especially for poorer kinds and those containing large quantities of metallic sulphides other than PbS.

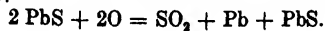
The process is carried out in two stages, firstly roasting in special reverberatory furnaces, and secondly reducing and melting in blast furnaces. The roasting is continued with addition of SiO_2 until only oxides and lead silicates are left. The reducing is done with addition of carbon (coke); other additions like iron stone, lime, &c. are intended to assist the formation of slags containing the less readily reduced metals. The temperature during reduction should not be too high.

For many years the process of lead smelting underwent little or no modification but recently a new process due to HUNTINGTON and HEBERLEIN (Germ. Pat. 95601) has become important. According to this method galena is mixed with 6–15 % CaO and heated to a dark red heat with a blast. After this, further heat need not be supplied as sufficient is developed by the reaction itself. The temperature rises to 700°C after which cooling to dark red heat takes place. During this process PbSO_4 is formed; little PbO is formed and no Pb; no lead is lost by volatilization. The hot roasted material is now treated with compressed air in a converter where — again without external heating — PbO and CaSO_4 are formed and SO_2 is evolved. The roasted material obtained by this method is reduced in blast furnaces at much less cost than is the material obtained by the old process. According to the experiments of DONALD CLARK the reaction equation given by the inventors, is wrong. It gives PbSO_4 as an intermediate product while CaPbO_3 must be regarded as being present. On a large scale crushed lime, galena and admixtures are mixed and heated in any kind of roasting furnace, when about one half of the S escapes; the granular product while still hot is introduced into the HUNTINGTON-HEBERLEIN converter, a conical iron vessel, and air forced through. The process takes 2–4 hours and lowers the percentage of sulphur from 10 % to 1 %. The mass is removed by tilting the vessel, broken up and removed to the blast furnace. Although considerable amounts of sulphur are still present no matte is formed. The process of the Germ. Pat. 142932 of blasting Pb ores in converters without the previous addition of CaO and roasting has been purchased by the owners of the HUNTINGTON-HEBERLEIN process.

An improvement is that described in the patents of SAVELSBERG according to which the mixture of galena and lime-stone with the addition of a large quantity of water is smelted in heated converters without previous roasting.

The process of BRADFORD and CARMICHAEL is also similar to that of HUNTINGTON-HEBERLEIN. Lead ores containing S are mixed with 10–35 % CaSO_4 , introduced into a converter which is heated from without until the lower portion ($\frac{1}{3}$ to $\frac{1}{4}$) is at a dark red heat; the mixture is then converted into PbSO_4 and CaS . Air is blown in and the CaS changed to CaSO_4 and PbSO_4 to PbO . As the amount of PbO increases the mass becomes pasty and calcium plumbate is formed. After cooling the mixture is melted in blast furnaces (Engl. Pat. 17580, 1902).

According to LAUR, Pb may be obtained without the use of fuel: Compressed air is blown into fused galena when a change corresponding to the following equation takes place:—



Half the lead is obtained as metal and the other half in the form of a black sublimate of PbS. If the ores are rich the heat developed in the process is sufficient to fuse a fresh quantity of galena. If the ores are not pure the heat of reaction is not sufficient to produce the required working temperature of 1100° ; in this case a "white turn" (so-called in contract with the other process) is put in, i. e. one lot of material is roasted completely to PbO so that the whole heat of combustion of the S may be employed. The mixture of the black and white products is then treated. The process takes place in cupola furnaces.

4. ELECTROLYTICAL PROCESSES. Various methods of this type have been proposed. The Electrical Lead Reduction Co. in their works at Niagara Falls places ground galena into hard lead vessels, dilute H_2SO_4 is added as electrolyte, and the whole electrolysed. Twelve vessels are placed one above the other, the galena forming the cathode and the bottom of the lead vessel above the anode. The reduction takes place with evolution of H and H_2S . The Pb separates in a spongy form which is used in the works for the preparation of lead compounds. — The Germ. Pat. 140317 has for its object the separation of Pb + PbO_2 from a solution of $\text{Pb}(\text{NO}_3)_2$ by electrolytical methods; the HNO_3 is neutralized by continually adding PbO.

The work lead obtained by one of the methods mentioned under 1—3 is contaminated by various substances. Purification is effected by liquation which consists in melting the lead in a reverberatory furnace with an inclined base. The lead melted slowly at low temperatures runs into a tank. This process is especially employed when lead containing copper is to be purified. The process of refining by melting and simultaneous oxidation varies according to the degree of purity of the raw material:— The continuously forming scum on the surface of the lead is removed — skimming process. In the poling process poles of green wood are dipped into the lead and stirred around. Another method of refining is that by steam; another process is described in the article on "SILVER".

Several electrolytical methods of refining lead have been proposed, though it is not quite certain which have proved reliable. According to KEITH anodes of work lead are used, a solution of PbSO_4 in sodium acetate serves as electrolyte and the cathodes are of brass on which the refined lead is deposited. According to BETTS (Amer. Pat. 713277 and 713278) the electrolyte used in refining should be a mixture of a lead compound and a reducing agent; the latter prevents the separation of Pb in a crystalline state the objectionable feature of KEITH's process. BETTS chooses for his electrolyte, lead silico-fluoride as lead compound and gelatine as reducing agent. Lead silico-fluoride is formed by the solution of the work lead anodes when hydro-fluosilicic acid is used as electrolyte. The cathodes on which the lead is precipitated are themselves of thin sheet lead. So far no electrolytical refining process for Pb has proved economical, though BETTS' method is spoken of favourably. In an American factory an electrolyte with 10 % free hydrofluosilicic acid and 5 % Pb is at present used; the vats have 20 anodes and 21 cathodes; the anodes are one inch thick, the lead cathodes produced electrolytically are $\frac{1}{16}$ inch thick, current 0.25 volt, 15 amperes per square foot.

Pure lead is bluish white with a high metallic lustre, though it rapidly turns grey in the air. S. G. 11.36—11.39; M. P. 334° ; B. P. about 1600° . As Pb is only touched very superficially by HCl and H_2SO_4 and the film formed prevents further action lead is used in making many vessels for chemical purposes. It is also used as material for water pipes, shot, and as a constituent of alloys.

Hard lead see "ANTIMONY ALLOYS".

Lead alloys.

1. **HARD LEAD**, see "ANTIMONY ALLOYS". Type metal is discussed under the same heading.

2. **SHOT METAL**. 0.2 to 0.8 % arsenic according to the pureness of the lead is mixed with it making it easier to cast and at the same time harder. The arsenic is not added to the molten lead in the metallic state but as realgar; As is liberated with formation of PbS.

3. **TIN-LEAD ALLOY**. Prepared by the usual melting process. The composition is as follows: 52 % Pb, 33 % Sn, 14 % Sb and 1 % As. Lead-tin alloys are much used, for instances as theatre jewellery (Fahlun diamonds, about 40 % Pb), as tin soldiers (up to 50 % Pb) for organ pipes (30 % Pb) and for many kinds of cutlery and plate; in the latter case there should not be more than 10 % Pb.

Lead colours.

1. **LITHARGE**. PbO. Obtained by heating lead in reverberatory furnaces. The temperature is not raised to the M. P. of the oxide. Less frequently it is obtained from $\text{PbCO}_3 + \text{Pb(NO}_3)_2$.

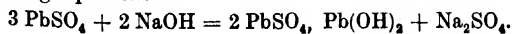
2. **WHITE LEAD** (Berlin white, Kremser white). Basic lead carbonate $2\text{PbCO}_3 + \text{Pb(OH)}_2$; it is produced in various ways:

a) **DUTCH METHOD**: Vinegar is poured over metallic lead and the jars in which the action takes place are imbedded in horse dung or tan. The basic lead acetate first formed is changed into white lead and neutral lead acetate by the CO_2 produced in the fermentation of the dung or tan.

b) **GERMAN METHOD** (Chamber process). The lead sheets hung up in chambers of wood or masonry are converted into lead acetate by the vapours of acetic acid. The latter is converted into white lead by introducing CO_2 . According to the Germ. Pat. 151514 the fermentation gases escaping in the manufacture of spirits and compressed yeast (containing water vapour, CO_2 , and a little alcohol) are used in the manufacture of white lead by conveying them (by means of compressed air) to special vinegar chambers, where the alcohol is oxidized to acetic acid; the vapours of acetic acid then enter the chambers containing the lead.

c) **FRENCH METHOD**. Litharge is dissolved in acetic acid and the basic lead acetate formed decomposed by CO_2 . White lead separates while neutral lead acetate remains in solution. This can be converted into the basic acetate by treatment with litharge. The process is therefore to a certain degree continuous. According to the Germ. Pat. 133425 this method is modified in so far as a solution of ammonium acetate is allowed to act on litharge under such conditions that litharge is dissolved by NH_3 , $\frac{1}{3}$ being converted into lead acetate and $\frac{2}{3}$ to basic acetate: the solution obtained is then precipitated by a solution of ammonium carbonate. The product is a white lead, fine grained and with good covering properties. The method of the Amer. Pat. 750541 is as follows:—PbO is mixed with acidified H_2O , heated to about 95° , the PbO converted by the action of acetic acid and CO_2 into carbonate and finally oxygen is allowed to act on the mixture. — According to the Germ. Pat. 158309 white lead with good covering properties is obtained as follows:—PbO (100 parts) suspended in 100 parts water is thoroughly incorporated with a solution of lead acetate (250 parts) in H_2O (650 parts), CO_2 is then passed through the whole. The amorphous white lead settles slowly and is pressed in a filterpress, washed, and dried.

d) **BRONNER'S METHOD**. (Germ. Pat. 52262). Freshly precipitated PbSO_4 is warmed with soda lye to 70° when basic lead sulphate is formed according to the following equation:



When, the basic sulphate is warmed with a soda solution it is easily converted into white lead:—



The English method formerly used is now rarely employed.

e) **ELECTROLYTICAL METHOD** (Germ. Pat.). An aqueous 1.5 % solution of 80 parts NaClO_3 and 20 parts Na_2CO_3 is electrolyzed, the anode consisting of soft lead and the cathode of hard lead. Current 2 volts, 5 amperes per square meter. The electrolyte must be kept slightly alkaline, and H_2O and CO_2 carefully introduced during the electrolytical process. Besides this one, several other methods of preparing white lead electrolytically have become known. In HARTMANN'S method, described under lead hydroxide in "LEAD COMPOUNDS" CO_2 is introduced during the electrolysis. The French Pat. 328490 has for its object the production of white lead by the electrolysis of a 1 % solution of common salt, using lead electrodes. The Pb(OH)_2 which dissolves is at the same time or subsequently exposed to the action of CO_2 .

f) **AMERICAN METHODS.** In America white lead (WINTER, *Zeitschr. f. angew. Chem.* 1905, 1179) is chiefly manufactured in the following way: Molten Pb is conducted through fine tubes into boxes. A jet of steam blows against the tubes so that the lead is turned into metallic spray. This lead dust is placed in rotating barrels together with dilute acetic acid. During the process which takes about 7 days, air, filtered combustion gases, and a little steam are continually blown into the barrels. The contents of the barrels are washed with water so that the unchanged lead sinks to the bottom. The white lead thus obtained is either dried or kneaded with oil.

White lead is frequently mixed with the much cheaper barium sulphate, BaSO_4 , giving a mixture of much less covering power. Mixtures of this nature are Venetian white with 50 % BaSO_4 , Hamburg white with 65 %, and Dutch white with 80 %.

The purest and best kind of white lead is Kremser white, sold in the form of hard plates. It may be made from any white lead prepared by the German or Dutch method. The white lead is not washed, and is dried slowly.

White lead:

Farbwerke-Aktien-Gesellschaft, Düsseldorf, Germany.

3. **MINIUM** (Paris red, Saturn cinnabar). Pb_3O_4 . Obtained by carefully heating PbO in muffle furnaces. The substance must not melt. The finest kinds are produced by heating white lead or lead nitrate to a gentle red heat in the oxidizing flame, or by heating PbSO_4 with NaNO_3 and Na_2CO_3 . Brilliant red powder, much used as a paint.

Iron minium (minium substitute) see "IRON COLOURS".

Read lead (Minium):

Farbwerke-Aktien-Gesellschaft, Düsseldorf, Germany.

4. **NAPLES YELLOW** (basic lead oxyantimoniate). At present usually obtained by melting oxide of antimony with litharge. The finest kinds are obtained from a mixture of one part potassium antimony tartrate, 2 parts lead nitrate and 4 parts common salt. It is heated gently in crucibles, and the substance while liquid is poured on to a cold metal plate and extracted with water: The Naples yellow remains on the plate. It is a fine colour, with good covering properties; used not only as an oil colour but also as a porcelain colour since it stands firing. It is decomposed by H_2S .

5. **CASSEL YELLOW** (Mineral yellow, Veronese yellow). Lead oxychloride, $\text{PbCl}_2 + 7 \text{PbO}$. It is obtained by melting PbO with NH_4Cl . The NH_3 set free, decomposes a certain amount of PbO with formation of Pb. The molten mass is poured off from the lead and allowed to cool in iron moulds to congeal. It is a beautiful crystalline yellow substance.

6. **PATENT YELLOW** (Turner's yellow, Montpellier yellow, English, yellow). This is also a basic lead chloride $\text{PbCl}_2 + 5 \text{PbO}$. It is obtained by treating litharge with a solution of common salt; the substance obtained is originally white turning a brilliant yellow after melting.

7. **WHITE LEAD COLOUR**. According to Germ. Pat. 153042 a white paint is obtained by mixing PbO with NaCl in presence of H_2O , neutralizing the mixture of PbCl_2 , Pb(OH)_2 and NaOH after removing the NaOH with H_2SO_4 or sulphates, stirring, washing, and pressing. The residue is stirred with drying oils. The product is a mixture of $\text{PbCl}_2 + \text{PbSO}_4$; it covers better than the latter alone and remains white when mixed with oils.

Lead chromates see "CHROMIUM COLOURS"; substitutes for white lead see "ANTIMONY COLOURS".

Lead colours:

Farbwerke-Aktien-Gesellschaft, Düsseldorf, Germany.

Lead compounds.

1. **LEAD ACETATE** (sugar of lead). $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 3 \text{H}_2\text{O}$. Generally prepared by dissolving litharge in acetic acid. Obtained pure by the action of vapours of acetic acid on PbO ; the latter is spread out on sieve-plates, a solution of lead acetate collects at the bottom of the vessels from which pure crystals are produced. Valuable details on the manufacture of lead acetate are given by C. BAUER in the Chem. Ztg. 1905, 1.

White tetra-hedral columns which slowly effloresce in the air. M. P. 75°C ; when the water of crystallization is removed it solidifies to a leafy substance which melts again at 280° . It dissolves in 1.5 parts water at 15°C and at 100°C in 0.5 parts. It is used in dye works and in calico printing works for mordanting, further for making lead-colours and preparations, varnishes, and medicaments.

TEST. The amount of acetic acid is determined by SALOMON'S method, by making the solution strongly alkaline with standard alkali in presence of phenolphthalein and re-titrating the excess with standard acetic acid until the red colour vanishes. The difference gives the combined acetic acid. — According to FRESSENIUS the Pb and acetic acid are determined as follows. The aqueous solution of 5 g in a 250 ccm flask is precipitated by an exact definite amount of H_2SO_4 in slight excess. The flask is shaken and filled up to the mark. Then water is added corresponding to the amount of precipitated PbSO_4 (S. G. 6.3), the shaking repeated, and then the mixture is filtered through a dry filter. The H_2SO_4 is precipitated by a solution of BaCl_2 in $\frac{1}{5}$ of the filtrate (50 ccm), the BaSO_4 is weighed and the lead is then determined from the amount of H_2SO_4 used in precipitating the Pb. Another 50 ccm are titrated with standard alkali and the acetic acid determined by deducting the amount of H_2SO_4 .

2. **BASIC LEAD ACETATE**. $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2 \text{Pb(OH)}_2$. It is obtained solid by stirring into hot acetic acid, a suspension of litharge in the proportion of 76 kg 30 % acetic acid to 120 kg litharge. It is used in the manufacture of chrome yellow and chrome orange.

A solution of basic lead acetate (*Liquor Plumbi subacetici*) is generally used. This latter which is $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{Pb(OH)}_2$ is produced by melting together 3 parts sugar of lead and 1 part PbO on the water bath. This is diluted with 10 parts H_2O and filtered. Colourless slightly alkaline liquid; clear at first but becoming milky on exposure to air, S. G. 1.235—1.240. It is used medicinally; also for weighting silk, for separating natural colours, for the preparation of white lead and aluminium acetate.

3. **LEAD BORATE**. It is rarely pure PbB_2O_6 but a mixture of several salts. To prepare it, calcined borax is ground with PbCl_2 (or another Pb salt); a very

intimate mixing and at the same time more or less complete chemical combination takes place. The salt is used as a siccativ for varnishes and oil paints.

4. **LEAD CHLORIDE.** PbCl_2 . Prepared by precipitating solutions of lead with HCl or BaCl_2 . It is a crystalline powder.

Small white silky crystals which dissolve in about 100 parts water at 15°C and in 30 parts at the boiling point.

ELBS obtained tetrachloride of lead PbCl_4 electrochemically by using two anodes, the lower one of Pb, the upper one of carbon. With suitable currents the Cl evolved at the carbon anode transforms all the PbCl_2 formed at the lead anode to PbCl_4 .

Lead oxychloride and basic lead chloride see CASSEL YELLOW and PATENT YELLOW under "LEAD COLOURS".

5. **LEAD CHROMATES.**

a) **NEUTRAL LEAD CHROMATE** (Chrome yellow). PbCrO_4 . It is obtained by acting on a lead compound with K_2CrO_4 or K_2CrO_7 ; further details see under CHROME YELLOW in "CHROMIUM COLOURS". The electrochemical method has recently become important: A 1.5 % aqueous solution of a mixture of 8 parts NaClO_3 with 2 parts Na_2CrO_4 is subjected to electrolysis. The anode consists of soft lead, the cathode of hard lead. Current 1.8 volts 0.5 ampere per square metre.

b) **BASIC LEAD CHROMATE** (Chrome red, chrome cinnabar, chrome orange). $\text{PbCrO}_4 + \text{Pb(OH)}_2$. Obtained by treating chrome yellow with caustic alkalies, or alkaline carbonates, or from basic lead salts by treatment with K_2CrO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$.

6. **LEAD RESINATE** (see "SICCATIVES"). It is produced by melting lead preparations with colophony, &c., or also by wet methods, precipitation, &c.

7. **LEAD HYDROXIDE**, see under No. 14 "LEAD OXIDES".

8. **LEAD CARBONATE.** PbCO_3 . It is produced by pouring a solution of lead nitrate into a solution of ammonium carbonate, or by passing CO_2 into a solution of lead acetate.

According to the Amer. Pat. 715214 lead carbonate is obtained by heating lead sulphate in an excess of a solution of alkaline carbonate. As a single treatment only effects a partial transformation the process must be repeated with fresh solutions of alkaline carbonate.

By another method (Germ. Pat. 140489) basic lead carbonate is produced by heating insoluble or lead salts soluble in water, with MgO and MgCO_3 in presence of H_2O ; the heating is best effected by steam.

Lead carbonate is a white amorphous powder.

9. **BASIC LEAD CARBONATE**, see WHITE LEAD under "LEAD COLOURS".

10. **LEAD LINOLEATE.** Obtained by boiling PbO with linseed oil; see "SICCATIVES".

11. **LEAD MANGANATE.** PbMnO_4 . Obtained by melting a mixture of manganese oxide and lead nitrate. It forms a green glass, which becomes brown by the absorption of atmospheric moisture.

12. **LEAD NITRATE.** $\text{Pb(NO}_3)_2$. Obtained by dissolving Pb, PbO or PbCO_3 in dilute HNO_3 and evaporating the solution. According to the Amer. Pat. 754609 substances containing lead are heated with hydrofluosilicic acid and then a nitrate of the alkali metals is allowed to act upon the lead salt with formation of $\text{Pb(NO}_3)_2$.

Crystals of S. G. 4.5. 100 parts H_2O dissolve 48 parts $\text{Pb(NO}_3)_2$ at 10° , and 140 parts at 100°C . It is used to prepare nitrogen peroxide NO_2 as it readily decomposes when heated: $2\text{Pb(NO}_3)_2 = 2\text{PbO} + 4\text{NO}_2 + \text{O}_2$. In much smaller quantities than the acetate it is used in calico dyeing and printing and in manufacturing lead colours; mixed with PbO_2 it serves as an igniter.

TEST. In order to determine the impurities the solution is precipitated with excess of H_2SO_4 , concentrated by evaporation, the precipitated PbSO_4 filtered off and the filtrate examined for Cu, Fe and Ca.

13. LEAD OXALATE. PbC_2O_4 . Obtained by precipitating neutral solutions of lead salts with oxalic acid. On heating it decomposes into Pb_2O , CO and CO_2 . It forms many double salts.

14. LEAD OXIDES.

a) LEAD MONOXIDE (Litharge, massicot). Massicot is obtained by roasting metallic lead or by heating PbCO_3 or $\text{Pb}(\text{NO}_3)_2$. Litharge is obtained in silver refining.

By a new process (Germ. Pat. 123222) PbO is made from galena by heating in the absence of air. A basic lead sulphate is formed which after cooling is converted into PbO by extraction with caustic alkalies. The alkali sulphate is removed by treating with hot water, the residual PbO dissolved in hot caustic alkali solution, and the solution reduced with Pb when PbO crystallizes out.

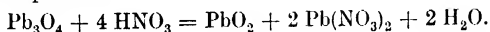
Massicot is a yellow amorphous powder; litharge when heated and cooled slowly is reddish, when rapidly cooled it is yellowish.

b) LEAD HYDROXIDE. $\text{Pb}(\text{OH})_2$. It is precipitated by NH_3 from solutions of lead salts in microscopic white crystals. According to the Germ. Pat. 113316 a particularly good white lead (q. v.) is produced by treating the precipitated $\text{Pb}(\text{OH})_2$ with CO_2 . According to the Amer. Pat. 758023 $\text{Pb}(\text{OH})_2$ is made from PbSO_4 by treating it with an excess of caustic alkali.

According to HARTMANN (Germ. Pat. 139068) lead hydroxide is obtained electrolytically by using anodes of metallic lead and cathodes of a metallic oxide (e.g. CuO); the oxide cathode prevents the precipitation of spongy metal.

c) RED OXIDE OF LEAD (minium). Pb_3O_4 . See MINIMUM under "LEAD COLOURS".

d) LEAD PEROXIDE. PbO_2 . The action of dilute HNO_3 on minium is shown by the equation:—



When Cl is conducted into alkaline solutions of lead or when hypochlorites are added PbO_2 is obtained. According to a new method (Germ. Pat. 124512 and 133379) PbO_2 is produced electrolytically from PbO . Electrodes which are not attacked are used, separated by a diaphragm. The litharge (in the form of an emulsion) is placed in the anode chamber while the cathode chamber contains NaCl solution. The conversion of PbO to PbO_2 is quantitative.

According to the Germ. Pat. 140317, PbO_2 (together with metallic Pb) is obtained by the electrolysis of a concentrated solution of lead nitrate. The nitric acid liberated at the anode is neutralized by the constant addition of PbO . The anodes are strong iron nettings, the cathodes iron rods covered with lead. The lead crystals settling on the cathodes are removed mechanically by pieces of wood. They collect on the bottom of the cell, while the PbO_2 is precipitated at the anode as a dense, solid covering.

The Germ. Pat. 162107 uses natural or artificial lead sulphides which are electrolyzed in acidified H_2O (or H_2O rendered conducting by salt) so that the PbS is oxidized to PbO_2 .

PbO_2 is a dark brown powder, insoluble in H_2O , which has powerful oxidizing properties.

15. LEAD PERSULPHATE (*Plumbum persulfuricum*). $\text{PbS}_2\text{O}_8 + 2 \text{H}_2\text{O}$. Obtained by the electrolysis of lead sulphate in H_2SO_4 . So far it has been of little technical value.

16. LEAD SULPHATE. PbSO_4 . It is obtained as a heavy white crystalline precipitate on addition of H_2SO_4 or a sulphate to lead salts. It is soluble in

about 23000 parts of cold water, but in presence of H_2SO_4 , it is almost insoluble.

According to Germ. Pat. 155106 pure white basic lead sulphate is produced by volatilizing lead sulphide ores in a layer of glowing coke and introducing air immediately above this layer, so that the PbS is oxidized.

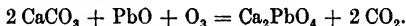
17. **LEAD SULPHIDE.** PbS . It occurs widely distributed as galena. It is obtained by melting together lead and sulphur, or by wet methods, e. g. allowing H_2S to act on a solution of a lead salt.

18. **LEAD THIOSULPHATE.** PbS_2O_3 . Obtained by the action of a solution of sodium thiosulphate on a solution of a lead salt. White powder, slightly soluble in water, more readily soluble in solutions of thiosulphates. It is used as part of non-phosphorous ignition substances, and possibly also in vulcanizing gutta-percha and caoutchouc.

Of the plumbates the following should be mentioned:—

19. **SODIUM PLUMBATE.** Na_2PbO_4 . It is obtained by dissolving oxide of lead in soda lye. It is used to dye hair and horn, to produce temper shades on brass and bronze, and in the manufacture of sodium stannate.

20. **CALCIUM PLUMBATE.** Ca_2PbO_4 . It is produced by heating an intimate mixture of limestone and litharge to a clear red heat at the same time introducing a strong current of air:



At low temperatures calcium plumbate is again decomposed when a current of CO_2 (furnace gas) is passed over it, oxygen being given off. This compound is therefore valuable as a source of oxygen (see special article). Much more important is, however, the use of this salt in the recent manufacture of phosphorus-free matches striking on any surfaces; see the article on "MATCHES".

Lead soldering. The oxy-hydrogen blow pipe is used. The mixtures are coal gas and compressed oxygen, or compressed hydrogen and compressed oxygen, or compressed hydrogen and blast air. As oxygen in large quantities promotes the oxidation of the metallic surfaces the last named combination — hydrogen and compressed air — is especially suitable.

A flame produced by compressed hydrogen alone, burning in atmospheric air, does not possess enough force. For this reason soldering methods observed so far have necessitated the use of a special air blast. Only by causing both gases, hydrogen and air, to escape with a certain force could the flame necessary in lead soldering be obtained.

The DRAEGER works, Lübeck, have now succeeded in constructing a burner with the same effect as the flame of a double blast though it uses compressed hydrogen only.

DRAEGER's force burners are independent of the addition of air as they automatically suck the air necessary for combustion by reason of the velocity of the escaping hydrogen. This is effected just before the mouth of the burner by a system of unions. The soldering implements of this new method therefore consist of bottle, valve, tube, and burner.

Leather. For preparation see "TANNING", "MINERAL TANNING", "CHAMOIS DRESSING".

Various kinds of leather are made, e. g. sole leather, upper leather, saddle leather, morocco leather, kid, wash leather, &c.

The process of DREHER is interesting in that the leather is prepared by the use of titanium salts and dyed at the same time. The hide is treated with solutions of titanium salts and tanning extracts to which dye extracts have been added, or the process is carried out with titanium salts, mordant dyestuffs and assistants. Salts of molybdenum have also been used for tanning and dyeing. See "MINERAL TANNING".

According to Germ. Pat. 160236, dyestuffs alone are used as tanning materials in a quick process which is complete in 24 hours. According to the specification almost any aniline dye may be used. Considering the great variety in composition of these dyes the method seems to be open to considerable doubt.

Leather glue see "GLUE".

Leather manufacturing.

Barberry juice (for fine-leather.):

Dr. Ernst Kumpf, Villach (Kärnten), Austria.

Leather meal see "MANURES, ARTIFICIAL".

Leather oils see "DEGRAS". In addition to degreas whale oil (blubber), stearine, tallow, bees' wax and on account of its power of emulsifying with water, wool fat are also used in the preparation of leather. Mineral oils are not suitable.

Leather substitutes. Various artificial products are used in place of leather, e. g. leather paper, imitation leather, artificial leather, *cuir factive*, &c. In order to prepare these, leather scraps are shredded and then felted together in the wet state as in the manufacture of paper. The nature of leather may be imparted to textiles by treating them with paste and coloured varnish, drying, polishing, and finally coating them with copal varnish. In other cases the fabrics (textiles of linen, cotton, wool or pulp, paper, &c.) are steeped in solutions of caoutchouc or glue. When glue is used, the outer layer is "tanned" either by aluminium acetate or $K_2Cr_2O_7$, or by vegetable tannins. See also "LINOLEUM".

According to Germ. Pat. 140424, in order to prepare artificial leather unhaird leather wastes are soaked in lime water until they begin to decompose. They are then thoroughly washed, shredded in disintegrators, placed in a bath of $ZnSO_4$ and dried *in vacuo* or in a current of dry air at a temperature not exceeding $70^\circ C$. During drying the mass is strongly compressed.

PEGAMOID is apparently prepared from nitrocellulose and camphor dissolved in some special solvent: the details of the process are kept secret. By transferring or rolling pegamoid on to paper and linen, articles closely resembling leather can be obtained. It is used for floor coverings, furniture, purses, bookbinding, &c.

Accounts have been given of a process for the manufacture of a leather substitute from rags or cotton. For this a patent has been applied for. The cotton waste is treated with 15 % NaOH, a portion of the liquid squeezed out, and the mass treated with carbon bisulphide until it is soluble in water.

Surface-roughened or felt-like woven articles are impregnated *in vacuo* with an aqueous solution of the substance and after the cellulose is fixed, the articles are treated with solutions of caoutchouc or guttapercha and finally, *in vacuo*, with dammar or quick lime. The articles so prepared should exhibit leather-like properties throughout their structure in contrast to goods prepared by other methods. Nothing is known as yet as to the success of the process. See also Germ. Pat. 172474 and 179577 and French Pat. 370616 and 371400.

Leblanc process see "SODA".

Lecithine. A glyceride of the fatty acids found widely distributed in the animal organism particularly in the brain, nerves, blood-corpuscles and in the yolks of egg. There are several lecithines, that most easily obtained being

Blücher.

the one containing stearic and palmitic acids. It is regarded as an ester of choline glycerophosphoric acid combined with stearic and palmitic acid as a glyceride. Lecithine is usually obtained from the yolks of egg. A modification of the ordinary process is given in French Pat. 371391.

It is a waxy, crystalline substance readily soluble in alcohol and ether. With water it swells up and gives an opalescent solution.

Lecithine yields brom- and iodo-derivatives which like the parent substance are used medicinally.

Lemon juice. In order to prepare it the fruit is peeled, pressed, and after removal of the pips squeezed out in linen bags. The freshly prepared juice is heated and after cooling, shaken with talc. When the talc has settled the juice is filtered. In order to preserve it, it is boiled with 10 % sugar and while still boiling poured into sterilized bottles which are at once sealed.

An artificial lemon juice is obtained by colouring an aqueous solution of citric acid.

TEST. HENSEL & PRINKE (Chem. Ztg. 1904, Rep. 39). A pure juice obtained from fresh fruit should contain not less than 5.2 % and not more than 7.6 % of acid. 100 g of juice should be coloured red-brown by the addition of 16 g of 10 % NH_4OH . It should not become cloudy on the addition of BaCl_2 . When 40 ccm alcohol are poured on to 100 ccm of the juice a white ring, due to the presence of albumin and pectine, should be observed.

Lemon, oil of. Obtained from lemon peel in the following way. The fruit is cut into four pieces and the peel removed. The latter is folded together and squeezed by a workman with his left hand against a sponge held in the right hand. The oil cells in the surface of the peel are broken and the oil is taken up by the sponge which is from time to time squeezed out into an earthenware vessel. After the water has settled the oil floating on the surface is removed and cleared by filtration.

Pale yellow to greenish-yellow oil with a strong smell of lemon peel. S. G. 0.858 to 0.861; B. P. about 177° ; (α)_D at $20^\circ + 60-64$. In addition to the terpenes pinene and limonene, the aldehyde, citral which imparts the characteristic odour to the oil, is also present.

Artificial lemon oils have been prepared by different methods. According to Germ. Pat. 134788 the following compounds are mixed:— limonene and phellandrene 92 parts, 7 parts of a mixture of citral, citronellal, geraniol, geranyl acetate, linalool, and linalyl acetate and 1 part of a mixture of nonylaldehyde and octylaldehyde. The quantities of the aldehydes may be varied according to the smell desired.

Lenicet. The trade name for a modification of aluminium acetate prepared by a patented process. A fine white odourless powder, soluble only with difficulty, with drying properties. Used in treatment of wounds and for perspiring feet. Sold in the form of powder, ointment, cream, &c.

Lentapaper see "PHOTOGRAPHIC PAPERS".

Lethalbline. A lecithine albuminate with 20 % lecithine.

Leuconine. An antimony preparation containing 97.74 % sodium met-antimoniate, recommended as a substitute for the more costly tin oxide for enamelling. Investigation has shown, however, that some antimony is dissolved by water, the acids in fruits, &c.

Leviathan see "BLEACHING".

Levuretine. A purified dry yeast used medicinally.

Ligroin see "BENZINE".

Lime. (Under this name are included LIMESTONE, CHALK, QUICKLIME and SLAKED LIME.)

Quicklime or caustic lime is obtained by burning limestone at a white heat. It is important that the CO_2 be allowed to escape freely. The lime-burning takes place in kilns or furnaces of different types according as to whether the process is continuous or interrupted. In the former case the quicklime is withdrawn at intervals and further supplies of limestone are introduced, while in the latter case the kiln has to become cool before the charge can be removed.

Quicklime obtained from limestone, marble, chalk, &c. remains unchanged in dry air but in presence of moisture is converted into calcium hydroxide. It is used to assist the formation of slags in the smelting of ores, for the manufacture of fire-proof crucibles, for removing water from liquids, in glass making, &c. &c.

When brought into contact with water quicklime is converted into slaked lime (calcium hydroxide $\text{Ca}(\text{OH})_2$). The "slaking" is accompanied by the evolution of a large amount of heat, and according to the amount of water used the slaked lime is obtained as powder, paste or as milk of lime. The filtered milk of lime is known as lime-water. A special process for the preparation of pure, dry, powdery slaked lime is protected by Germ. Pat. 151949.

Calcium hydroxide readily takes up CO_2 from the air with formation of CaCO_3 ; upon this fact is based its use in mortars (q. v.). In consequence of its strongly basic properties, $\text{Ca}(\text{OH})_2$ is used in the preparation of NaOH and KOH , of NH_3 from NH_4Cl , &c. It is used for making bleaching powder, in the soda, sugar, tanning, fat, dyeing, and bleaching industries; in the manufacture of manures, for the purification of feed-water for boilers, as a disinfectant &c., &c.

TEST. a) QUICKLIME. To estimate the free CaO 100 g of a good average sample are weighed and carefully slaked. The paste is then placed in a $\frac{1}{2}$ litre flask which is filled up to the mark with water. 100 ccm are withdrawn with a pipette, shaking constantly during the process. This is introduced into another $\frac{1}{2}$ litre flask which is filled up to the mark, and from the thoroughly mixed diluted solution 25 ccm, corresponding to 1 g of lime, are withdrawn.

The titration with $\frac{1}{10}$ N. HCl (using phenolphthalein as indicator) must be carried out slowly and with frequent shaking, until the pink colour disappears. At this point the whole of the CaO is saturated while the CaCO_3 is not attacked. 1 ccm $\frac{1}{10}$ N. HCl = 0.028 g CaO .

In order to estimate the CO_2 , the CaO and CaCO_3 present are determined by dissolving in $\frac{1}{10}$ N. HCl and titrating back with $\frac{1}{10}$ N. NaOH . The amount of CaO determined as above must be deducted from the total and the amount of CaCO_3 is thus obtained.

b) SLAKED LIME. The CO_2 is determined as described above. To determine the water present about 1 g is weighed in a closed weighing bottle and heated in a platinum crucible, at first gently and then to a strong red heat. After cooling, the loss of weight, due to water and CO_2 is determined. By subtracting the amount of CO_2 previously found the water is calculated. Milk of lime is determined with a hydrometer by means of the following table.

If the milk of lime be thin the S. G. must be read quickly before the lime has time to settle; if thick, the cylinder in which the S. G. is being determined

De- grees Baumé	Weight of 1 l. milk of lime g	CaO in 1 l. g	CaO weight %	De- grees Baumé	Weight of 1 l. milk of lime g	CaO in 1 l. g	CaO weight %	De- grees Baumé	Weight of 1 l. milk of lime g	CaO in 1 l. g	CaO weight %
1	1007	7.5	0.745	11	1083	104	9.00	21	1171	218	18.61
2	1014	16.5	1.64	12	1091	115	10.54	22	1180	229	19.40
3	1022	26	2.54	13	1100	126	11.45	23	1190	242	20.34
4	1029	36	3.54	14	1108	137	12.35	24	1200	255	21.25
5	1037	46	4.43	15	1116	148	13.26	25	1210	268	22.15
6	1045	56	5.36	16	1125	159	14.13	26	1220	281	23.03
7	1052	65	6.18	17	1134	170	15.00	27	1231	295	23.96
8	1060	75	7.08	18	1142	181	15.85	28	1241	309	24.90
9	1067	84	7.87	19	1152	193	16.75	29	1252	324	25.87
10	1075	94	8.74	20	1162	206	17.72	30	1263	339	26.84

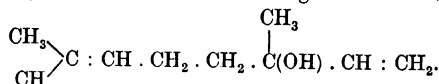
must not be too narrow. The hydrometer is gradually introduced and the cylinder slowly rotated until the instrument comes to rest.

Acetate of lime:

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Limonene see "TERPENES".

Linalool. A terpene alcohol of the following constitution:—



It is a very frequent constituent of many essential oils: it occurs in both optically active forms. In order to prepare the laevo form oils containing linalool are fractionally distilled and the fraction coming over between 190° and 195° collected. By treating coriander oil in this way d-linalool is obtained. It is used for the preparation of linalyl acetate (q. v.) and is always present in good lily of the valley perfumes.

Linalyl acetate. $\text{C}_{10}\text{H}_{17} \cdot \text{C}_2\text{H}_3\text{O}_2$. Prepared by heating molecular quantities of linalool and acetic acid for some hours under a reflux condenser, distilling in steam, washing with Na_2CO_3 and fractionating *in vacuo*. It almost invariably accompanies linalool. Bergamot oil owes its characteristic smell to this compound which also has a marked influence on the odour of lavender oil.

Linon (FLAX). The bast fibre of the flax *Linum usitatissimum* prepared for spinning. The plants before they are quite ripe are spread out to dry and the seed shells and twigs removed by combing with iron combs. The bast fibre is loosened by retting i. e. by a process of fermentation. The retting is carried out either by dipping the bundles of flax into water or by steam and warm water. The fibres are then separated from the wood by "bruising", i. e. the woody stem is broken by hammering with hammers, blunt knives or ribbed rollers. The flax fibres are finally scraped off the broken up stem (oakum, tow) and are spun to linen. The length of the fibre is 20—40 cm, and the width 0.012 to 0.026 mm.

Linon dyeing. The linen fibre, so far as colours and dyes are concerned, is very much like the cotton fibre. Therefore all that need be said about linen dyeing will be found in the article on cotton dyeing and the articles there mentioned. At the same time it should be remarked that on linen the dye should be if anything faster, as it undergoes washing more frequently than cotton.

Linoleum. This is a leather substitute (see special article) consisting chiefly of cork and wood dust, oxidized linseed oil, earth (mineral) colours, resin, various siccatives and jute. The cork dust is obtained from the wastes of cork works by means of cork breakers, mills, &c.; sand sieves, magnetic apparatus (to remove iron particles) and sifting machines are also used.

The oxidized linseed oil is agitated by mixing rollers and then boiled with resin and drying media to form the so-called cement. The cement boilers used are of various descriptions. When the viscous liquid leaves the cement boilers it passes between two smooth rollers and is then received in boxes where it solidifies to cake. These cement cakes are now treated with cork or wood dust and mineral colours in different mixing machines, the last of which compresses the substance strongly. It leaves the machine in the shape of small sausages. These are flattened out between mixing rollers and finally broken up to a fine grained mass. On leaving the mixing houses the linoleum substance is pressed in calanders on to the jute base, great pressure and considerable heat being employed. After the surface is well pressed and smoothed the linoleum strips, known as cork carpets, are passed over coolers.

The Engl. Pat. 5789 (1903) deals with the treatment of wood oil to obtain a substance suitable for the manufacture of linoleum: Chinese wood oil is heated to 180° to 250° and the resulting elastic solid product is mixed with linseed oil or some other drying oil or resin oil which may previously be oxidized or solidified. Resins, oils, siccatives &c. may be added; mixing is effected by grinding or heating. The substance is said to have a much lower M. P. than pure solidified wood oil.

The great advantages of linoleum (its durability and its properties as a non-conductor of heat and sound) have in a short time made its use very widespread. When linoleum is to be laid over a wooden floor a freshly prepared paste of rye meal and dextrine made with boiling water is used. In case of cement floors, stone floors, &c. linoleum must be fastened by a special cement.

Linoleum keeps exceedingly well if it is waxed slightly every two months. See also Germ. Pat. 175414 and 185182.

Linseed oil. A fatty oil obtained by pressing or extracting the seeds of *Linum usitatissimum*. When the seeds are pressed cold an almost colourless oil is the result (cold-drawn oil). This is used for culinary purposes. For all other purposes the pressing is done hot and is repeated two or three times. The oil thus prepared is yellow and has a peculiar taste and odour: it quickly becomes dark brown and viscid and turns rancid. It is generally decolorized by treatment with a 30 % solution of FeSO_4 or with KOH followed by $\text{K}_2\text{Cr}_2\text{O}_7$ and HCl . In addition to these methods a process of exposing the oil in open vessels to the action of sunlight is sometimes adopted. Shaking with sea-sand and salt water is also carried out.

The Engl. Pat. 26929 (1902) protects a process for preventing linseed oil from becoming cloudy or gelatinous. The process consists in the addition of small amounts of some alkaline powder, e. g. CaO .

Linseed oil is a drying oil: S. G. (at 15°) 0.924 to 0.938; iodine number 133—141; saponification number 193.7. It is used principally in the manufacture of varnishes (see **LINSEED OIL VARNISHES**), printing, cement and soap manufacture, &c.

Linseed oil varnishes. Oily varnishes made by boiling linseed oil alone or with substances which give off oxygen. The formation of a varnish depends upon the drying properties of the linseed oil. Oxygen is absorbed, the liquid thickens and finally hardens. During this process the linolic and linoleic acids are converted into oxy acids. The substances added to linseed

oil for making varnishes are, litharge, sugar of lead, oxides of lead, manganese hydroxide, manganese borate, manganese edioxide. Recently metallic compounds of resin acids have been much employed for rendering the drying more rapid. See "SICCATIVES".

For making varnish oil extracted in the cold is best. It should be pale and clear in colour. It is boiled in pots, best by super heated steam or over an open fire. It is most frequently boiled with 3 % of litharge. The heat is kept up for several hours and the mixture is continually stirred. Varnishes which contain no lead are necessary for all objects which come in contact with H_2S . They are prepared as above described, compounds of manganese, for instance 0.25 % manganese hydroxide or 1—2 % of manganous borate being added instead of the lead compounds. The prepared oil varnishes increase in value by keeping. They also dry more rapidly if the heating during the manufacture is carried out at a high temperature. Linseed oil varnish is prepared also by a cold process as follows. 20 parts of oil are rubbed together with 1 part of litharge, and the oil then shaken with a clear solution of basic acetate of lead (1 part sugar of lead, 1 part litharge and 5 parts of H_2O). The mixture is afterwards again shaken with dilute H_2SO_4 to remove the lead. There is now a movement in favour of the cold thin fluid varnishes. In England and America especially the thick boiled varnishes are being superseded by those prepared in the cold, the reason given being that the durability of a painting is in proportion to its colour and varnish contents, and that a paint, with a high proportion of colour can be only made with thin unheated varnish.

No details can be given of the many other methods of preparation of varnish, but mention should be made of the fact that linseed oil varnishes are sometimes treated with ozone.

The purity of the oil is of great importance in the manufacture of varnish. It has been recommended to bleach the oil in sunlight, by exposing it in vessels with loosely fitting covers. Another proposition has been put forward to bleach the oil by shaking it together with sea sand and salt water. Experiments have also been carried out for purification by treatment with $KMnO_4 + HCl$, followed by filtration through animal charcoal. According to Germ. Pat. 163056, the impurities are frozen out by cooling the oil to $-20^\circ C$, then heating carefully again not above $0^\circ C$ and finally filtering it off from the impurities.

The high price of linseed oil is the cause of the appearance of so many substitutes for linseed oil varnish.

Germ. Pat. 129808 gives the following substitute. Fish, cod or whale oil is cooled with continuous stirring to -5 to -25° and the fluid part separated. This fluid is said to serve the same purpose as linseed oil.

According to Germ. Pat. 104499 and 131964 castor oil is dry distilled. The residue which has good drying properties is used as a substitute for linseed oil. Another process (Germ. Pat. 141258) is to heat pine resin or colophony with concentrated H_2SO_4 until the mixture no longer froths. The product of the reaction after dilution with refined mineral oil e. g. lamp oil forms a substitute for linseed oil. According to Amer. Pat. 729838 creosote oil or tar oil is stirred with a solid alkali, allowed to settle, the sediment drawn off, the oil washed repeatedly with water, the water removed and dry compressed air pumped into the oil which is then decomposed with PbO . The product is finally mixed with cotton seed or some other vegetable oil.

Liqueurs see "ALCOHOLIC LIQUORS".

Liquor anthracis. A tar solution obtained by dissolving coal-tar in a mixture of benzene and alcohol. A solution of potassium sulphide is frequently added.

Liquor anthracis is used in the treatment of various diseases.

Lithio piperazine. A preparation of piperazine and lithium salts combining the solvent action on uric acid of the former with the diuretic properties of the latter. Daily dose 1.0 to 3.0 g.

Lithio piperazine:

Dr. C. L. Marquart, Chem Fabrik, Beuel a. Rhein (Germany).

Lithium and Lithium compounds.

LITHIUM. Li. Atomic weight = 7.03. Silver-white light metal, S. G. 0.59, the lightest of all solid substances; M. P. 180°. It is closely related to Na, in the metallic state as well as in its compounds; it decomposes H_2O at ordinary temperatures. Above 200° it ignites in the air and burns with an intense flame. The metal is obtained by the electrolysis of lithium chloride. It has no industrial importance.

LITHIUM COMPOUNDS. They occur as silicates in small quantities in several minerals, for instance petalite, lepidolite and spodumen; together with Na and K they are present in most mineral waters containing common salt. From these they reach the animal and vegetable organism. Lithium compounds, like lithium chloride $LiCl$, lithium bromide $LiBr$, lithium carbonate Li_2CO_3 , lithium sulphate Li_2SO_4 and others are used therapeutically. Lithium carbonate is used, in consequence of its property of dissolving uric acid, in gout, gravel, stone, &c., partly as such, partly in the form of mineral waters containing lithium. Lithium salicylate has been recently used more than the carbonate as it is more readily assimilated by the stomach.

Citrate of Lithium:

Dr. C. L. Marquart, Chem. Fabrik, Beuel a. Rhein (Germany).

Lithofracteur see "DYNAMITE".

Lithographic colours.

Lithographic colours:

E. T. Gleitsmann, Dresden, Germany.

Lithopone see "ZINC COLOURS".

Litmus. A blue dyestuff obtained from various species of lichens. The plants are crushed and allowed to ferment with potashes and ammonia water. When the mixture has turned blue sufficient gypsum and chalk are added and the pasty mass moulded into cubes which are dried in the air.

The most important constituent is azolitmine which in the free state is red, while its alkali salts are blue.

Litmus is used only as an indicator.

Logwood (CAMPEACHY WOOD). The heart wood of the American *Haematoxylon campechianum*. The colouring matter, haematoxylin, forms yellowish, transparent crystals and is converted by oxidation into the dyestuff haematein; the oxidation takes place in the presence of aqueous solutions of alkalis. According to the strength of the oxidizing agent the colours obtained can be varied. With alkalis a violet-blue shade is obtained which owing to the formation of dark coloured, insoluble lakes can be changed by metallic salts. Chromates and copper salts give blacks. Logwood extracts are obtained by extracting the wood with water and concentrating *in vacuo*. By heating logwood extract with formaldehyde a chemical compound is obtained (Germ. Pat. 155630). By the action of solutions of alkali nitrites on dilute logwood extracts a solid dyestuff is obtained (Germ. Pat. 162010 and 162726).

Lokao (CHINESE GREEN). A lac obtained from the bark of *Rhus utilis*. It is not used in Europe, but is employed in China for the production of beautiful shades of green on silk and cotton.

Loretine = m-iodo-o-oxy-quinoline-anasulphonic acid. $C_9H_4NI(OH)SO_3H$. According to the Germ. Pat. 72924 o-oxyquinoline is sulphonated; the sulphonic acid is neutralized with K_2CO_3 in aqueous solution, boiled with KI and bleaching powder and the cooled mixture again finally neutralized with HCl. The Ca salt of loretine which separates is washed and the free acid obtained by adding HCl.

Sulphur-yellow crystalline powder, almost odourless and tasteless, slightly soluble in H_2O and alcohol. It is used in treating wounds as an odourless and non-poisonous substitute for iodoform. Sodium and bismuth salts (the latter internally for chronic diarrhoea) are used.

Loretine has been recently used in another form; see "GRISERINE".

Losophane = Tri-iodo-m-cresol. $C_6H(I_3)OHCH_3$. It is obtained by the action of potassium iodide on the sodium salt of o-oxy-p-toluic acid. It forms colourless odourless crystals, almost insoluble in H_2O . It is used externally in skin diseases, gatherings, &c.

Lunar Caustic (*Silver nitrate*). Obtained by dissolving work-silver in nitric acid. In order to remove the copper, the solution is evaporated to dryness, ignited gently (to convert the $Cu(NO_3)_2$ into CuO), extracted with water and the solution evaporated until it crystallizes. The crystals are as a rule melted and cast into sticks.

Pure white rhombic tables M. P. 218° . The crystals when exposed to light turn violet. Silver nitrate exerts a caustic action and is poisonous it is used in medicine and photography, for the preparation of silver mirrors and for other purposes.

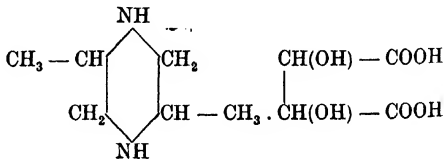
Lupuline see "HOPS".

Lustring see "SILK DYEING".

Luteoline see "WELD".

Lycetol. $C_6H_{14}N_2 \cdot C_7H_6O_6$. According to its constitution it is dimethyl-piperazine tartrate

Produced by neutralizing dimethylpiperazine with tartaric acid. A colourless crystalline powder M. P. $250^\circ C$, easily soluble in H_2O . In consequence of its strong solvent action on uric acid it is prescribed in cases of gout and chronic rheumatism, in doses of 1 to 1.5 g, twice daily in a glass of water to which 1.5 g M_4CO_3 are added.



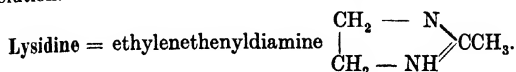
Lyddite see "PICRIC ACID".

Lygosine preparations. Lygosine is di-o-dioxydibenzalacetone. It is prepared in the form of its Na salt, by the condensation of salicylic aldehyde with acetone in presence of strong soda lye. The sodium salt and also the quinine salt are used for medical purposes, both in the treatment of wounds (as powder, gauze and ointment) and in the form of douches in cases of uterine gonorrhoea.

Lysalbinic acid see "PROTALBINIC ACID".

Lysargine. A new name for colloidal silver (see COLLARGOL). It is prepared by the use of protalbinic acid (q. v.) and lysalbinic acid, forming magnificent

steelblue leaves dissolving freely in water to give a yellowish-brown coloured solution.



By dry distillation of sodium acetate with ethylenediamine hydrochloride, ethylenethenyl hydrochloride is obtained from which the free base is readily set free by treatment with concentrated KOH solution. Long, white, very hygroscopic crystalline needles; M. P. 105—106° C, readily soluble in H₂O, alcohol and ether. By reason of its solvent action on uric acid it is prescribed for diseases of the kidneys and bladder and for gout.

Lysiform (*Liquor formaldehydi saponatus*). Solution of formaldehyde in alcoholic potash soap solution. Germ. Pat. 141744 protects the method of manufacture of a similar preparation with aqueous potash soap solution, while the Suppl. Germ. Pat. 145390 deals with the treatment of formaldehyde with potash soap under pressure in the absence of any solvent.

Lysiform is a disinfectant.

Lysol (*Liquor cresoli saponatus*). Disinfectant, effective in consequence of the cresols (q. v.) contained. The property of being soluble in H₂O is imparted by treatment with soap or by boiling tar oils with KOH lye and fats. A 0.5—2 % solution is much used for disinfecting the skin and mucous membranes, in surgery and veterinary medicine for destroying plant parasites, for cleaning floors, walls, &c.

Lytrol. A new liquid disinfectant with only faint poisonous properties. It is an alcoholic solution of potassium β -naphtholate equal to 20 % β -naphthol. It is used like lysol.

M

Mace, oil of. (*Oleum macidis*). Obtained by distillation of the seeds of *Myristica officinalis*. It is an essential oil, colourless or pale yellow turning to brown, clear and somewhat viscid with a strong smell and a mild taste with an after-taste that is sharp and aromatic. S. G. (at 15°) 0.91 to 0.93; B. P. 175° to 200°; (α)_D = + 10°. The main constituents are myristicene and pinene. It is used in perfumery and in the manufacture of liqueurs.

Mafurrah tallow see "TALLOW, VEGETABLE".

Magnalium see "ALUMINIUM ALLOYS".

Magnesia articles. Experiments in the laboratory of the Kgl. Porzellan-manufactur, Berlin, have shewn that commercial articles of many kinds even those of large dimensions satisfying the demands of various branches of industry can be made of pure magnesia. It is for instance possible to make pipes 80 cm long, 7 cm in diameter 7.5 mm thick, and vessels up to 50 cm high of any diameter and thickness. Tests as to their safety have shewn them not to break nor change shape even when suddenly heated in the oxygen blow pipe. Pipes of pure magnesia shewed no depreciation nor electrolysis at a temperature of 1750° C in the electric furnace. In appearance these articles of pure magnesia are much like tempered porcelain.

Magnesite. A mineral crystallizing in rhombohedra which occurs both in grains and in the massive state. It consists of magnesium

carbonate MgCO_3 , though frequently contaminated with basic carbonates, iron compounds, &c. S. G. 2.9–3.1, hardness 4–4.5. Magnesite is used for the preparation of other compounds of magnesium and CO_2 and for the manufacture of fireproof vessels, bricks, and cements. For the three last mentioned purposes it is converted into magnesium oxide MgO by heating. For this reason magnesia is frequently termed burnt magnesite.

Magnesite:

Willy Manger, Dresden, Germany.

Magnesium. Mg. Atomic W. = 24.36. Formerly prepared by the reduction of MgCl_2 with Na; at present, however, it is produced solely by electrolytical methods, partly by the electrolysis of MgCl_2 and partly by the decomposition of carnallite ($\text{KCl} \cdot \text{MgCl}_2 + 6 \text{H}_2\text{O}$). Either a cast steel vessel is employed for the electrolysis or one of copper is used which serves as cathode at the same time. Also vessels of non-conducting materials, such as porcelain, earthenware &c., have been used, cylindrical metal sheets acting as cathodes. Almost invariably carbon is used as anode.

Mg is a silver-white metal that does not change in dry air though it oxidizes slightly in moist air, S. G. 1.70. The hardness is the same as that of calc spar. Melting point $700\text{--}800^\circ \text{C}$. It can be hammered, rolled, filed, polished, drawn to wire, is not dissolved by alkalis but readily by dilute acids. In thin ribbon or powder it burns with a white flame of strong actinic power, which is much used for purposes of projection and photography (flash-light). Beyond this, Mg is but little used except (recently) in the shape of magnalium, i. e. an alloy of Al (see „ALUMINIUM ALLOYS“).

Magnesium:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Magnesium compounds.

1. MAGNESIA see 11 a MAGNESIUM OXIDE.

2. MAGNESIUM ACETATE. $\text{Mg}(\text{C}_2\text{H}_3\text{O}_2)_2$. Prepared by treating MgCO_3 with acetic acid, and in the purest form by the precipitation of MgSO_4 with barium acetate. It is an easily soluble salt which crystallizes badly; sold in solid form and in solution.

3. MAGNESIUM BORATE. Occurs naturally in many minerals, e. g. boracite, stassfurtite, &c. It is artificially prepared by boiling a mixture of magnesium sulphate and borax. A white salt $\text{Mg}_3\text{B}_2\text{O}_6 \cdot \text{H}_2\text{O}$ separates, which re-dissolves on cooling. By fusing a mixture of MgO with excess of boric acid at a very high temperature the same compound is formed in the anhydrous state.

4. MAGNESIUM CARBONATE (*Magnesia alba*), MgCO_3 . Occurs as magnesite (q. v.) and combined with CaCO_3 as dolomite. From the latter magnesium bicarbonate (MgHCO_3) is produced by burning, and then super-saturating with CO_2 . The Mg is dissolved before the Ca. The carbonate is also produced from $\text{MgO} + \text{NaHCO}_3$ with water. According to Germ. Pat. 142558 powdered carbon or paraffin is added to the aqueous emulsion of burnt magnesite under pressure. This is done to increase the yield; the carbon powder or paraffin retains the CO_2 and separates the magnesite particles.

According to the Engl. Pat. 25776 (1901) magnesium carbonates of certain compositions and physical properties are precipitated by adding the calculated amount of calcined magnesite to a filtered solution of MgHCO_3 . The temperature of precipitation is of considerable importance. If for instance normal MgCO_3 is required in heavy crystalline form the requisite amount of calcined magnesite is added to the cold MgHCO_3 solution. The mixture is then shaken and warmed to about 74°C .

The preparation of magnesium carbonate with $3 \text{H}_2\text{O}$ is the object of the Germ. Pat. 143594, 144742 and 159870. According to the first of these,

it is obtained by the action of gases containing CO_2 on moist magnesium hydroxide: the gases must be present in large excess and the amount should be increased as the formation of MgCO_3 proceeds. According to the second patent magnesium hydroxide is moistened with dilute potassium chloride solution and treated with CO_2 at 40°C . The third patent allows the gases to act under a pressure of at least 3 atm.

See "POTASH".

Magnesium carbonate is a white substance, very light when prepared by the ordinary methods. It is used medicinally, as tooth powder, polishing powder, cleaning powder, and for the preparation of MgO and CO_2 .

5. MAGNESIUM CHLORIDE. MgCl_2 . Technically prepared from the residual lyes of the Stassfurt potassium chloride works where carnallite (and kainite) are treated. The lye containing MgCl_2 , MgBr_2 and MgSO_4 is evaporated in wrought iron pans to 42°Bé , and on cooling crystallizes and $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ separates. Fused MgCl_2 is obtained by melting this compound in furnaces, and also by evaporating the residual lye to 45°Bé . — According to Germ. Pat. 161662 crystallized $\text{MgCl}_2 + 6\text{H}_2\text{O}$ is dried by heating for 6 hours at a temperature of $125\text{--}175^\circ\text{C}$ in *vacuo*.

6. MAGNESIUM CITRATE. $\text{Mg}_3(\text{C}_6\text{H}_5\text{O}_7)_2$. Produced from MgCO_3 and citric acid. It is obtained in a crystalline form by allowing the solutions to run into alcohol. Technically however it is generally produced as follows: A powdered mixture of 105 parts citric acid and 30 parts burnt magnesia is carefully melted at $100\text{--}105^\circ\text{C}$ and while soft poured on to a china slab; when cold the mass is ground to a fine powder.

7. MAGNESIUM HYPOCHLORITE see BLEACHING.

8. MAGNESIUM NITRATE. $\text{Mg}(\text{NO}_3)_2$. It is obtained by neutralizing MgO with HNO_3 and evaporating. The result is monoclinic crystals of the constitution $\text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}$, which deliquesce in moist air and dissolve in alcohol. Magnesium nitrate is especially used in the preparation of incandescent gas mantles to render the tops of the mantles more rigid.

9. MAGNESIUM OLEATE. Obtained by saponification of the glycerides of oleic acid with MgO or MgCO_3 . With other things it is used as an addition to benzene in chemical cleaning works to lessen the inflammability. See also "ANTIBENZENE PYRINE".

10. MAGNESIUM OXIDES.

a) MAGNESIUM OXIDE (BURNT MAGNESIA, *Magnesia usta*). MgO . It is obtained by heating magnesite or artificially prepared MgCO_3 . The MgO obtained from the latter is denser, the higher the temperature and the denser the MgCO_3 . When MgCO_3 is precipitated hot the result is the so-called *Magnesia usta ponderosa sive anglica*. This is a very dense, absolutely white MgO , with an asbestos-like lustre and of considerable hardness.

b) MAGNESIUM PEROXIDE. MgO_2 . Obtained by the action of sodium peroxide Na_2O_2 (see "SODIUM COMPOUNDS") on MgSO_4 . There are also other methods of production which (in part at least) are kept secret. According to the Amer. Pat. 709086 a cold slightly acid solution of magnesia (e. g. MgCl_2 solution) is treated with barium peroxide or its hydrate, the resulting precipitate of MgO_2 is filtered, washed and dried. According to Germ. Pat. 179981 Na_2O_2 is added to a solution of MgCl_2 at a temperature below 20°C . The product containing 27—30 % MgO_2 is precipitated by alcohol in the form of a powder. If the temperature is lowered by adding NH_4Cl and ice the product contains 35—40 % MgO_2 . According to Hrnz' method (Germ. Pat. 151129) it is prepared electrolytically in a cell fitted with a diaphragm. The anode space contains aqueous MgCl_2 solution, the cathode space a mixture of hydrogen peroxide and MgCl_2 solution. When the current (6—7 volts) passes, MgO_2 separates readily at the platinum cathode, from which it drops back into the electrolyte, and is collected, washed and dried at a moderate heat.

According to Germ. Pat. 171372 (MERCK) pure dry MgO is mixed with the requisite amount of chemically pure H_2O_2 and allowed to stand for a day. (The initial rise of temperature is checked by cooling.) A paste of MgO_2 is obtained which is drained and dried at a moderate temperature.

According to French Pat. 354249 (KIRCHHOFF and NEIRATH) commercial H_2O_2 is allowed to act upon MgO or precipitated $\text{Mg}(\text{OH})_2$.

MgO_2 is used instead of H_2O_2 in bleaching and is not quite as alkaline as the latter. It is also used medicinally, internally in cases of gout and externally for wounds and skin diseases (in the form of ointments).

The MgO_2 prepared by HINZ' is sold under the protected name "Novozone". — See 12. PERHYDROL OF MAGNESIA. The pure MgO_2 of KIRCHHOFF and NEIRATH is sold as HOPOGAN and that of MERCK as magnesium perhydrol.

11. MAGNESIUM PHOSPHATE. $\text{MgHPO}_4 + 7 \text{H}_2\text{O}$. Prepared by precipitating a solution of MgSO_4 with Na_2HPO_4 . White crystalline powder, sparingly soluble in H_2O , converted by heat into magnesium pyrophosphate $\text{Mg}_2\text{P}_2\text{O}_7$; when boiled with water it decomposes into trimagnesium phosphate $\text{Mg}_3(\text{PO}_4)_2 \cdot 7 \text{H}_2\text{O}$ and H_3PO_4 .

12. MAGNESIUM SILICATE. It is found in various compounds in many minerals, partly hydrated, partly anhydrous. Some of these are talc, mer-schaum, serpentine, olivine, the double salts augite, hornblende, asbestos, &c. A white gelatinous precipitate $3 \text{MgSiO}_3 \cdot 5 \text{H}_2\text{O}$ is produced by precipitating solutions of magnesium salts with sodium silicate.

13. MAGNESIUM SULPHATE (Epsom salts). MgSO_4 . It is chiefly produced from Abraum salts (q. v.). The sparingly soluble kieserite $\text{MgSO}_4 + \text{H}_2\text{O}$ is separated from the chlorides by washing. Magnesium sulphate, which crystallizes with $7 \text{H}_2\text{O}$, is purified by re-crystallization from hot H_2O .

According to the Amer. Pat. 714984 a Mg-compound, which is decomposed by $\text{SO}_2 + \text{H}_2\text{O}$ is subjected to the action of sulphur vapour SO_2 , atmospheric air and moisture, so that MgSO_3 and MgSO_4 are formed. The MgSO_4 which is soluble in H_2O is then separated from the insoluble MgSO_3 and the latter converted into MgSO_4 by oxidation.

Magnesium sulphate ($\text{MgSO}_4 + 7 \text{H}_2\text{O}$) is a salt crystallizing in colourless rhombic prisms with an intensely bitter taste. 100 parts H_2O dissolve about 25 parts at 0° , 30 parts at 10° , 35 parts at 20° , nearly 50 parts at 50° and 135 parts MgSO_4 at 105° (saturated solution). It is used in the preparation of K_2SO_4 and BaSO_4 , for dressing cotton fabrics, for weighting silk and paper for whitening wool, and as a drug.

14. MAGNESIUM SULPHITE. $\text{MgSO}_3 + 6 \text{H}_2\text{O}$. Obtained by decomposing MgCO_3 with SO_2 in presence of H_2O , or by mixing and heating the solution of equal parts of crystalline MgSO_4 and crystalline Na_2SO_3 ; in the latter case $\text{MgSO}_3 + 6 \text{H}_2\text{O}$ separates when the solution cools. The salt must be kept from the action of air and moisture as it easily becomes oxidized to sulphate; 1 part dissolves in 20 parts cold H_2O . Magnesium bisulphite $\text{MgH}_2(\text{SO}_3)_2$ may be obtained by passing SO_2 into water in which MgO is suspended.

15. MAGNESIUM THIOSULPHATE. MgS_2O_3 . Obtained by treating solutions of magnesium salts with calcium thiosulphate CaS_2O_3 or sodium thiosulphate $\text{Na}_2\text{S}_2\text{O}_3$.

Magnetite lamps. A modification by STEINMETZ of the electric arc lamp. The electrodes are of magnetite powder (mixed with titanium and other substances) stamped out in iron tubes.

Magolan (Calcium anhydrooxydiaminephosphate). An organic compound containing phosphorus recommended for treatment of *Diabetes mellitus*.

Maize starch see "STARCH".

Malabar tallow see "TALLOW, VEGETABLE".

Malarine. Acetophenonephenetidine. $C_6H_5C(CH_3) : N \cdot C_6H_4OC_2H_5$. It is prepared (Germ. Pat. 87897) by heating equivalent amounts of acetophenone and paraamidophenetol under a reflux condenser in presence of a condensing agent (this last named is not essential).

Pale yellow crystals, with a faint aromatic taste. M. P. 88° : almost insoluble in water, readily soluble in ether and hot alcohol. It is used as an antipyretic and antineuralgic.

Malonal. A preparation intended to replace veronal (q. v.).

Malt. Under this name is understood grains of corn which have been caused to sprout. During the process diastase is formed. Diastase is a ferment which has the property of converting starch into sugar. Only barley malt is used in the manufacture of beer. For making spirits, however, in addition to barley, malt of wheat and rye is also used. The method of preparing the malt is given in detail with tables in the article on BEER. First the barley is steeped in a cemented or iron steeping trough, 130 litres of water being used for every hl of barley. The average time for steeping is 60—72 hours. The temperature during this time should not exceed $15^\circ C$.

The swollen barley is then removed from the trough, spread out on a withering floor and turned about at regular intervals. The temperature in the malting room should be between 7 and $10^\circ C$. Inside the heaps the temperature will be much higher, but should never exceed 15 — $19^\circ C$. The barley is allowed to germinate for 5—6 days if for making spirits; if for beer the process is allowed to go on for 7 days.

Instead of shovelling the corn about on the malting floor, use is now made of the newer method, the so-called mechanical pneumatic malting process. The steeped barley or corn is placed in drums or boxes, through which an air current of a certain temperature and containing the requisite amount of moisture is conducted. The drums or cylinders rotate; the boxes have a turning apparatus inside. The moist ("green malt") if intended for spirits is best used at once, while that intended for brewing must first be dried. After drying, the bean-like taste of malt disappears and the product of the roasting acquires the peculiar aroma so valuable for the flavour of the beer. At the same time the sugar contents increase, while the water sinks from 40 % to 2 %. Malt driers of very varied constructions are used. Formerly smoke driers or kilns were much in use; in these the malt itself came into contact with the hot gases. At present all, or at any rate most malt is air-dried. Compare also the article on DRYING. The warming of the malt must be done very gradually. It is first made air-dry at 30 — 37° , then heated further to 75° and finally roasted at 80 — 100° according to the kind required. The dried malt is then cleaned in a winnower and thus freed from the shoots which cause a bitter taste. The last process is the grinding of the cleaned malt in special mills.

In order to give a dark colour to beer a malt is used which is obtained by roasting malt that has been moistened and again dried in roasting cylinders at a temperature of 150 — 200° until caramel is formed. For pale beer the green malt is allowed to develop sugar and is then roasted at the lowest possible temperature.

Malt extract. Obtained by soaking ground malt in water, pressing and concentrating *in vacuo*. It forms a yellowish-brown liquid containing diastase which is used alone or mixed with other substances (e. g. iron, quinine, iodine, cod-liver oil, &c.) as a strengthening agent, &c.

Other malt preparations are used for similar purposes.

Malt extract Vacuum apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).
 Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Malt syrup Vacuum apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Manganese. Mn. Atomic weight = 54.94. Obtained from the oxides by reducing with finely divided carbon at white heat. It is most conveniently obtained by means of the electric furnace, adding lime and fluor-spar to prevent oxidation. The metal may also be obtained from $MnCl_2$ by Na or by electrolysis. The simplest method of obtaining pure carbon-free Mn is by igniting a mixture of aluminium and manganese oxide (GOLDSCHMIDT's method of aluminothermy, see "THERMITE").

A greyish-white metal of variable hardness (approximately like steel). It is brittle and can be powdered. S. G. 7.8—8; M. P. about $1900^{\circ}C$. It oxidizes rapidly in moist air and decomposes H_2O ; it is dissolved even by weak and by dilute acids. Mn is harder and less attacked when C or Si is present. It is used to add to other metals, especially to iron and copper (see "MANGANESE ALLOYS").

Manganese alloys. Ferromanganese and manganese steel will be found under "IRON ALLOYS", manganese bronze under "BRONZES".

1. **CUPROMANGANESE.** Obtained by the simultaneous reduction of the oxygen compounds of the two metals. It is produced with 20 and 30 % Mn, free from iron, or with 2—4 % iron. It is chiefly used to make manganese bronze (see "BRONZE").

2. **MANGANINE.** Alloy of 12 % Mn, 84 % Cu and 4 % Ni. Coefficient of expansion 0.00001—0.00002. Specific resistance $0.43 \text{ ohm } \frac{m}{mm^2}$. In consequence of its high specific resistance it is used for electric resistance measures and regulators. The temperatures between 10 and 30° , i. e. those generally met with in electric measurement produce an alteration of the resistance which is small enough to be neglected even in accurate work, as it amounts to ± 0.00001 of the whole resistance per degree C.

3. **MANGANESE ALUMINIUM BRONZE.** The Germ. Pat. 144340 protects the preparation of such bronzes, the contents of aluminium amounting to half that of manganese (10 % and less); Pb, Zn or Ni &c. may be added to increase its casting qualities or to affect other properties.

Manganese Brass:

Jenoquel & Hayn, Hamburg.

4. **MAGNETISABLE MANGANESE ALLOYS.** According to the Germ. Pat. 144584 manganese alloys of high magnetic properties are obtained by introducing the elements Al, Sn, As, Sb, Bi or B into cupromanganese; the alloys must contain at least 3 % of the elements above mentioned and as a rule not less than 9 %.

5. **DELALOT'S ALLOY.** 80 parts Cu, 2 parts Mn, 18 parts Zn and one part calcium phosphate. At first the copper is melted, the manganese is gradually mixed in, and the calcium phosphate after the latter is dissolved. The slag is removed and the zinc added about 10 minutes before casting. To further the melting process $\frac{1}{2}$ part of calcium fluoride, $\frac{1}{2}$ part borax and one part charcoal may be added.

Manganese colours.

1. **MANGANESE WHITE** (Manganous carbonate). $MnCO_3$. $MnCl_2$, an important by-product in the manufacture of chlorine (q. v.), is used as a starting

point. The manganese liquors are precipitated with Na_2CO_3 . At first only a little soda is added to precipitate the iron and after settling the liquid is drawn off and then completely precipitated.

2. **MANGANESE VIOLET** (Nuremberg violet, manganic phosphate). Pure MnO_3 is fused with H_3PO_4 , the melt extracted with ammonium carbonate, filtered and evaporated. The residue is then fused again. After boiling again with H_2O the fine violet paint is obtained. For **UMBER** and similar natural manganese colours see "MINERAL COLOURS, NATURAL".

Manganese compounds.

1. **MANGANESE ACETATE**. $\text{Mn}(\text{C}_2\text{H}_3\text{O}_2)_2$. Obtained by treating MnSO_4 with lead acetate or calcium acetate. Obtained pure by dissolving MnCO_3 in acetic acid and evaporating to crystallisation point. It is sold either in solution, or crystallized with 4 H_2O . The crystals are reddish and are soluble in H_2O and alcohol.

2. **MANGANESE BORATE**. MnB_4O_7 , generally called **SICCATIVE**. For its preparation MnCl_2 solution from the manufacture of Cl (see under "MANGANESE COLOURS") is used; the iron is precipitated with milk of lime and the clear solution allowed to run into borax solution at not more than 40°C ; by adding a little NH_3 the precipitate becomes more dense. It is dried at a gentle heat. The preparation contains as a rule a little common salt and borax as the precipitate would otherwise turn brown when washed. It is used as an excellent siccativ mixed with dissolved linseed oil and resin, for impregnating leather. It is also used in the preparation of nickel, &c.

3. **MANGANESE CARBONATE**. MnCO_3 . Occurs naturally as manganese spar, obtained artificially by precipitating a solution of a manganous salt with Na_2CO_3 . It is white hydrated powder.

4. **MANGANESE CHLORIDE**. MnCl_2 . As pointed out it is obtained commercially from the waste liquors of the chlorine industry (manganese dioxide method, see "CHLORINE"). It is prepared by evaporating the liquors to remove HCl , diluting with H_2O and then adding Na_2CO_3 solution to the fourth part of the liquid. The MnCO_3 precipitated is after washing boiled with the rest of the liquid, the Mn dissolves again while the Fe is completely separated as $\text{Fe}_2(\text{OH})_6$. When the solution is filtered and evaporated light red crystals of $\text{MnCl}_2 + 4\text{H}_2\text{O}$ form which deliquesce in the air. It is used in dyeing. (The chlorine waste liquors are chiefly used to recover MnO_2 , see "CHLORINE".)

5. **MANGANESE RESINATE**. It is prepared by melting and precipitating (see "SICCATIVES"), and is an important drying medium in the manufacture of varnishes, &c.

6. **MANGANESE OLEATE**. An important dryer in the manufacture of varnishes, &c.

7. **MANGANESE OXALATE**. $\text{MnC}_2\text{O}_4 \cdot 5\text{H}_2\text{O}$. Obtained by precipitating concentrated solutions of manganese salts by treating moist manganese carbonate with an aqueous solution of oxalic acid. White crystalline powder, sparingly soluble in H_2O . Considered an excellent siccativ.

8. MANGANESE OXIDES.

a) **MANGANOUS OXIDE**. MnO . Obtained as a greyish-green powder by heating manganese oxalate or manganese carbonate in hydrogen; or by heating the same compounds with exclusion of air. It is used as a green paint.

b) **MANGANESE SESQUIOXIDE**. Mn_2O_3 . Obtained by gently heating manganous nitrate, and also from the chlorine liquors. It is a dark brown powder.

c) **MANGANESE HYDROXIDE**. Found naturally as manganite and produced artificially by oxidation of manganous hydroxide in the air. The latter is produced by precipitating solutions of manganous salts with NaOH . Manganese

hydroxide is a dark brown powder, used for dyeing textiles, also as a porcelain colour and as an ingredient in boiled linseed oil for varnishes.

d) **MANGANESE DIOXIDE.** MnO_2 . Occurs naturally as pyrolusite (q. v.). It is prepared artificially from chlorine liquors. It is a dark brown or black powder, decomposing when heated with evolution of O. Dissolves in HCl with evolution of Cl.

e) **MANGANESE TRIOXIDE.** MnO_3 and **MANGANIC ACID** H_2MnO_4 are without industrial importance.

f) **MANGANESE HEPTOXIDE** Mn_2O_7 , and **PERMANGANIC ACID** HMnO_4 are without technical importance; for the permanganates see under the respective metals.)

9. **MANGANOUS SULPHATE.** MnSO_4 . Obtained by dissolving manganese carbonate in dilute H_2SO_4 ; also by heating equal parts of pyrolusite and anhydrous FeSO_4 and extracting with H_2O , and by several other methods. It forms crystals of a delicate pink colour with 4–7 H_2O , according to the temperature of formation. It is used in dyeing, porcelain painting, and the preparation of other manganese compounds.

Manganese Compounds:

Willy Manger, Dresden, Germany.

Manures, artificial. Artificial manures are generally classified according to their composition into four or five classes, those containing potassium (potash manures), lime (lime manures), nitrogen (nitrogenous manures), phosphoric acid (phosphatic manures), and finally those which are mixtures.

1. POTASH MANURES.

Potash manures are the abraum salts (q. v.) including crude kainite, potassium magnesium sulphate, potassium sulphate, potassium magnesia (potash manure) and concentrated potassium salts obtained by calcining salts containing less potassium (especially potassium chloride). Carnallite and kieserite are also used as manures.

2. LIME MANURES.

Where the soil contains little lime various calcium compounds, especially calcium hydroxide and calcium carbonate are used for manuring. According to experiments of GERLACH and SCHULZE calcium carbide residues can be successfully used as lime manures without harm.



3. NITROGENOUS MANURES.

The manures containing nitrogen are classed as inorganic and organic manures. Belonging to the former class are Chili saltpetre and ammonium sulphate. Organic nitrogenous manures include blood meal, horn meal, flesh meal, and leather meal.

Blood meal is produced by drying coagulated blood on grids; the shell-like pieces are ground and sold. Blood meal contains on an average 14 % nitrogen and 0.5 to 1 % phosphoric acid.

Horn meal, which also contains 14 % nitrogen (or more) is obtained from hoofs, claws and horns by treating with superheated steam, drying and grinding. Flesh meal see under 5. **MIXED MANURES.**

Leather meal contains only 6–11 % nitrogen. Scrap leather is steamed, dried on grids and ground.

In addition to these, numerous other substances and mixtures are used as nitrogenous manures. Many patents deal with the production of manures containing much nitrogen (and potassium) from molasses- and distillers' wash, the liquor from wool washing, &c.

Bacterial manures also belong to this class. It has been found that certain plants, especially leguminous plants are able to assimilate the nitrogen of the air. This is accomplished with the assistance of certain soil bacteria with which these plants enter into symbiosis; curious nodules on the roots indicate the presence of these colonies of bacteria. After this was observed and experience had shown that the fertility of the soil on which these *Leguminosae* (lupines, clover, peas, &c., &c.) had been grown could be considerably raised by favouring the growth of these bacteria colonies, cultures were put on the market under the name of bacterial manure.

Experiments made with the object of rendering available atmospheric nitrogen for manuring have increased in number, FRANK'S method appears to be practical and economical. See CALCIUM CYANAMIDE under "CALCIUM COMPOUNDS".

4. PHOSPHATIC MANURES.

While formerly bones were the chief material used in producing phosphatic manures, at present the North American phosphorites and apatites are the chief raw materials. Besides these natural phosphorites there is Thomas meal (phosphate meal), i. e. the ground slag from the Thomas process (see "IRON").

Natural phosphorites are not used for manuring in their insoluble state, but are converted into a more soluble form. The best known phosphatic manure is superphosphate.

As regards the manufacture of superphosphate see the special article "SUPERPHOSPHATE". The raw material used in its manufacture is insoluble tricalcium phosphate, which is only assimilated by plants with difficulty. It is decomposed by treatment with H_2SO_4 , when mono-calcium phosphate soluble in water and $CaSO_4$ are formed. The mixture of mono-calcium phosphate and $CaSO_4$ is called SUPERPHOSPHATE. The manufacture of superphosphate has recently been much improved, a fact to which numerous patents bear witness. The most recent of these, like the Amer. Pat. 736730 which is a slight modification of the original superphosphate method, and the Germ. Pat. 146060 and 157150 treat of the production of a phosphatic manure by electrolytical methods.

Other inventors have attempted to render available the phosphoric acid in raw phosphates by fusing apatite with carnallite. Engl. Pat. 10461 (1902) appears to be somewhat curious. Iron phosphate is obtained as manure, by stirring a dilute solution of Fe_2Cl_6 with a solution of sodium pyrophosphate.

The so-called double superphosphates are manures containing about twice as much water-soluble phosphoric acid as the usual superphosphate; they are treated of in the article on "SUPERPHOSPHATE".

Thomas slag, basic slag (see "SLAGS") is as a rule allowed to lie for a year before being ground to a powder in ball mills. Frequently the liquid slag is mixed with phosphorites containing a high percentage of P. The value of Thomas phosphate, like that of all other phosphatic manures is determined by the amount of phosphoric acid soluble in citric acid, since it is considered that phosphoric acid soluble in citric acid is readily taken up from the soil.

According to a recent method the expensive stamping and grinding of the Thomas slag is rendered unnecessary. The slag is placed in an old boiler and subjected to the action of steam under a fairly high pressure; in a few hours the lime is slaked and falls into a very fine powder. With proper arrangements the powdered slag can be taken from the boiler in a perfectly dry state. The amount of phosphoric acid soluble in citric acid in slag produced by this method is 2 to 2.5 % higher than that in the slag produced by stamping and grinding. According to the results of experiments a great part of the phosphoric acid is soluble in water.

The value of Thomas phosphate slag as a manure is increased by a process due to TH. KNOESSEL (Germ. Pat. 128213) which at the same times makes

a rational use of the waste liquors from sulphite-cellulose works. These liquors were not only completely useless but their removal caused much expense and trouble. According to KNOESEL'S patent these waste liquors are concentrated to a syrupy consistency (25° Bé) and mixed with about the same amount of Thomas phosphate slag thus yielding a dry mixture. By this method the solubility in citric acid of the phosphoric acid of Thomas meal is raised almost to the maximum possibility, e. g. from 73 to 98 $\frac{0}{100}$.

The Swedish Pat. 18401 (1903) protects three modified methods of producing manure: molten acid slags are mixed with a raw phosphate, e. g. Apatite, Florida phosphate, &c. cooled and ground.

5. MIXED MANURES.

These are manures containing nitrogen and phosphoric acid and sometimes potassium, e. g. bone meal, flesh meal and fish guano and some artificial manures. Real Peru guano being a natural product does not come under this heading, at least not before it is treated with sulphuric acid (see "GUANO").

For the manufacture of bone meal the bones of slaughtered animals are cleaned, crushed in bone-breaking machines and heated with steam under a pressure of 4 atmospheres. After steaming the bones are dried on grids, broken up in stamp mills and then finely ground by rollers. Steamed bone meal contains 4—5 % nitrogen, 20—24 % phosphoric acid, and not more than 6 % fat.

According to Germ. Pat. 156356 bone meal is treated with the concentrated solution of a ferric salt until liquefaction takes place; after some time the mass solidifies. The result is a finely divided ferric phosphate which is readily soluble in dilute acids and is an excellent manure.

For the production of flesh meal carcasses of horses and other animals are used. In order to prevent the spread of disease the flesh is sterilized with steam under 4—5 atm. This process also disintegrates the substance. After 6—8 hours the fat and glue water are removed, the flesh and bone substance dried and ground. In a similar way the so-called Fray-Bentos Guano is produced from the residues of the manufacture of meat extracts (LIEBIG).

Fish guano is similar in composition to bone meal; it is made from fish (too small for sale) and from various parts of the whale and cod. The material is first treated in hydraulic presses to remove the oil and a great part of the water. The fat is then separated by boiling in open vessels and the glue by steaming under pressure (in closed vessels). The material is pressed out in hydraulic presses, dried on grids, ground and sifted. The composition of fish guano naturally varies considerably, the average is 7—9 % nitrogen and 12—14 % phosphoric acid.

The Germ. Pat. 157276 produces manure containing N and P from shells.

A new manure THOMAS-AMMONIA PHOSPHATE LIME is made by a special method (intended to avoid the usual loss of nitrogen). Thomas slag is mixed with ammonium sulphate. It contains besides not inconsiderable quantities of CaO, about 5.5 to 6 % easily soluble N and about 8 % phosphate soluble in citric acid.

6. SILICATE MANURE.

In his admirable book "Die chemische Industrie des Deutschen Reiches im Beginne des XX. Jahrhunderts" WITT points out that soluble silicates, e. g. water-glass and potassium silicate possess great possibilities as manures, particularly in growing maize and cereals which contain much silica. The plants cannot assimilate silicic acid in the form of quartz, and in America the soil is supplied with silicic acid in the hydrated form (e. g. siliceous earth). Witt remarks that water-glass would be a far better siliceous manure, especially potassium water-glass on account of the potassium contained.

EXAMINATION. The International Congr. for Applied Chem., Berlin 1903, has agreed to the following examination of artificial manures:

SAMPLES.

1. Samples not properly taken are to be refused by the examiners, or the fact to be pointed out in the report.
2. Proper samples are those which left the last railway station or docks in the presence of witnesses of both parties, or were taken by an expert under oath in accordance with the regulations set forth below.
3. Samples of manufactured material are to be taken from every tenth sack, or when the material is packed loose from at least ten different places by means of tubes.
4. Of raw material every 50th vessel (i. e. 2 %) is to be emptied on to the test heap. After the first sifting the amount of water is to be determined in a sample at least the size of a hazelnut. The material is then treated like manufactured material.
5. The samples which must weigh about 300 g must be placed loose in strong, clean and perfectly dry glass vessels.
6. At least three samples must be taken and sealed hermetically with the seal of the sampler.
7. The label is to be affixed with the same seal and is to bear the signature of the sampler.
8. The samples must be kept in a cool, dark and dry place.

PREPARATION OF THE SAMPLES.

- a) Dry specimens of phosphates or other artificial manures may be sieved and then mixed.
- b) Moist manures which cannot be treated like this must be prepared by carefully hand-mixing.
- c) For raw phosphates and bone charcoal the water is to be determined.
- d) For substances in which the amount of water contained is altered by powdering the water must be determined in the fine as well as in the coarse material and the result of the analysis calculated for the original coarse substance.

METHODS OF ANALYSIS.

I. Determination of water. 10 g of the substance are used; drying to be done at 100° until the weight is constant. Substances containing CaSO_4 are to be dried for 3 hours.

II. Determination of insoluble matter. 10 g substance are used: a) the portion remaining after dissolving in mineral acids is heated so as to make SiO_2 insoluble; b) the residue after treating with water is dried at 100° until constant in weight.

III. Determination of phosphoric acid. A. Making the solutions. 1. For P_2O_5 soluble in water 20 g substance are shaken for 30 minutes in a liter flask with about 800 ccm water and the flask then filled to the mark. The solutions of so-called double superphosphates must be boiled with the addition of a little HNO_3 before precipitation of P_2O_5 to convert the pyrophosphoric acid present into orthophosphoric acid. N.B. If P_2O_5 soluble in citric acid is to be determined in superphosphates it is to be done by PETERMANN's method. 2. For total P_2O_5 5 g of the substance are boiled with *Aqua regia*¹⁾ or 20 ccm HNO_3 and 50 g conc. H_2SO_4 for 30 minutes in a 250 ccm flask

¹⁾ See the table at the end of this article.

which is then filled up to the mark. 3. Thomas phosphate¹⁾. a) P_2O_5 soluble in citric acid: 5 g substance are used and shaken for $\frac{1}{2}$ hour with 2 % citric acid solution at a temperature of $17\frac{1}{2}^{\circ}C$ in an apparatus making 30–40 revolutions per minute. The vessel used is a 500 ccm flask rinsed with 1 ccm alcohol to prevent the substance from settling on the walls. b) Total P_2O_5 ²⁾: 10 g substance are used, shaken in a 500 ccm flask with 25 ccm water and then boiled with 50 ccm conc. H_2SO_4 for 30 minutes with frequent stirring. The flask is then filled. — B. Examination of the solution. 1. Molybdate method (FRESENIUS and WAGNER). 2. Citrate method. 3. Free acid. a) The aqueous solution A I is mixed with methyl orange and titrated with caustic soda, or b) determined in alcoholic solution by gravimetric analysis.

IV. Determination of oxide iron and alumina. To be made according to EUGEN GLASER's method as modified by R. JONES, or by HENRI LASNE's method. The method used is to be indicated.

V. Determination of nitrogen: 1. Nitrate nitrogen. Direct methods only are to be used. a) Reduction methods of G. KUEHN, ULSCH, DEVARDA, and KJELDAHL-JODLBAUR. b) Gas volumetrical methods. LUNGE, SCHLOESING-GRANDEAU. 2. Ammonia nitrogen. The determination is to be made by distillation with magnesia; for ammonium superphosphates the solution mentioned under III A I is to be used. 3. Total nitrogen. In presence of nitrates and ammonium salts to be made by KJELDAHL-JODLBAUR's method. 4. Organic nitrogen. In absence of nitrates and ammonium salts to be made by KJELDAHL's method or by combustion with soda lime.

VI. Chlorates and perchlorates. To be determined together, being equally harmful.

VII. Determination of potassium. To be made by the platinochloride or perchlorate process.

VIII. Determination of lime and magnesium. This can be done by TACKE's titration method or by gravimetric analysis.

Table of uniform nomenclature of the reagents and apparatus used in the examination.

Names	S. G.	Contents.
1) Sulphuric acid	1.40	50 parts H_2SO_4
2) Conc. sulphuric acid	1.84	100 " H_2SO_4
3) Nitric acid	1.20	32 " HNO_3
4) Conc. nitric acid	1.52	100 " HNO_3
5) Hydrochloric acid	1.12	24 " HCl
6) Conc. hydrochloric acid	1.20	39 " HCl
7) Ammonia	0.96	10 " NH_3
8) Conc. Ammonia	0.91	25 " NH_3
9) Aqua regia	$\left\{ \begin{array}{l} 1.12 \\ 1.20 \end{array} \right.$	$\left\{ \begin{array}{l} 3 \text{ " hydrochl. acid} \\ 1 \text{ " nitric acid} \end{array} \right.$
10) Citric acid		20 g. free acid in 1 l
11) Rotating apparatus		30–40 revolutions per min.
12) Shaking "		150 " " "

Artificial manures plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

¹⁾ Thomas phosphate meals containing apparently coarser parts are sifted through a 2 mm sieve. Lumps remaining in the meshes are removed by light pressure. The P_2O_5 is then determined in the sifted portion and the result calculated for the whole.

²⁾ When fine meal is to be examined a 0.17 mm sieve is to be used.

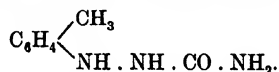
Bone meal manufacturing apparatus:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Leather meal plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Maretine = m-tolyhydrazide of carbamic acid.



It forms white tasteless crystals. M. P. 183—184° C. Sparingly soluble in cold, more readily in hot H₂O and in alcohol. It lowers the body temperature very considerably and is said to be a good febrifuge. It is stated that the temperature is lowered very gradually and that the lowering is maintained for a considerable length of time. It is much recommended for the early stages of tuberculosis. A series of favourable reports on its effects is counterbalanced by several unfavourable ones.

Margarin. Beef suet freed from stearine, not to be confounded with margarine.

Margarine (artificial butter). It is made from animal fat, generally beef suet. The suet is put through a mincing machine, mixed with 0.1 % solution of potash to which is added a small amount of the stomach of a pig and then heated to 45°. The fatty and fleshy portions are thus separated, and the fat is filtered off. To this is added 2 % of salt, after which it is allowed to cool very gradually to about 20° C (16—24 hours.) The greater part of the stearine present in the fat separates in the form of crystalline grains during this cooling. It is separated from the liquid oleine by pressing. The stearine is used for making candles (q. v.).

The oleo-margarine is then mixed with milk and churned. It is also advantageous to add 1 kg of chopped milk glands to every 300 kg of oleine. The butter formed by churning is made to solidify by the addition of cold water. Additions of butter colouring, butter esters, oil of peanuts, and similar materials make the product still more like butter.

The manufacture of margarine has been much improved of late years, and numerous new patents dealing with this branch of industry have been taken out. The Germ. Pat. 112687 and 116792 aim at making the product keep fresh for a longer time by sterilizing the oleo-margarine, and then mixing it with artificial milk, containing no sugar. The same purpose is aimed at by the Germ. Pat. 128729, according to which the volatile fatty acids of butter are mixed with the emulsion of milk and sterilized oleo-margarine. The Germ. Pat. 135081 deals with the production of a margarine which keeps remarkably well. The product is made free from nitrogenous constituents as far as possible, by mixing the fats with the products of the steam-distillation of milk, and suitable aldehydes. The latter substances improve the taste and smell.

There is no doubt that milk is of great importance in the manufacture of margarine. The Germ. Pat. 140941 recommends the addition of kephir.

Many processes, some of which are patented have been devised with the object of giving margarine certain properties of butter such as browning and frothing in the pan. Yolk of egg and sugar are added for this purpose. According to Germ. Pat. 127376 an addition of 0.1 % of cholesterine is employed, and Germ. Pat. 142397 proposes lecithine for the same purpose.

Casein precipitated from skim-milk by pure cultures of the lactic acid bacteria, sterilized cream and egg-yolk are recommended as additions (Germ. Pat. 170163).

According to Germ. Pat. 173112 the proteids which cause frothing and browning are separated from natural butter by a process of melting, and these are added to the margarine.

A special method of manufacture is protected by Germ. Pat. 185786.

Margol seems to hold its own against all the other substances and preparations for giving margarine the taste of butter. It is a mixture of volatile fatty acids.

In Germany margarine must by law contain 10 % of sesame oil to render detection of the artificial butter easy, to prevent it from being sold as real butter or from being used as an adulterant.

Melted margarine, that is margarine freed from water and proteids, is also an article brought on the market as an economical substitute for melted butter.

In consequence of the increasing price of animal fats, larger quantities of cocoa nut oil are being used in the manufacture of margarine. This material, however, must be added to the margarine itself after the latter has been kneaded to a thick semi-liquid paste. It must then be very rapidly mixed in, so that as little air as possible comes in contact with the product. If the oil is to be added to make melted margarine the latter must first be freed from water. On no account must the vegetable oil be added before churning, or the product will become rancid. Cocoa nut oil or fat is also now made into margarine without the addition of any animal fat or milk by mixing with solutions of yolk of egg and salt.

TEST. BAUDOUIN'S reaction is always used in testing for sesame oil (see „REAGENTS“). The reliability of this test has, it is true, been called in question by several authorities, but the objections do not appear valid. Compare the above test with SOLTSIEN'S reaction (see „REAGENTS“).

FENDLER recommends the following as a test for yolk of egg. A sample of the margarine is shaken with a 2 % solution of NaCl at 50°C, cooled, filtered, and finally dialysed. Should the fluid remain cloudy after 6 hours, but clear either completely or nearly on adding NaCl, the presence of yolk of egg is proved. The reaction is based on the fact that vitelline dissolves in 1 % solution of NaCl, but not in weaker solutions nor in water. This test was given by FENDLER in a lecture given at the Intern. Congress for Applied Chemistry in Berlin 1903.

Machines for manufacturing margarine:

Werner Pleiderer & Perkins Ltd., Peterborough.

Massicot (lead oxide) see „LEAD COMPOUNDS“.

Mastic. The resin of the evergreen shrub *Pistacia Lentiscus* which is cultivated in the Mediterranean area, particularly in Chios. Numerous longitudinal cuts are made in the bark, and from these the resin exudes in transparent drops which soon solidify to granular masses. The purest kind of mastic is in the form of drops, while the impure common kinds are in lumps and are cloudy in appearance.

Pure mastic is greenish to yellowish, transparent, with a glassy lustre and covered with white dust. It is hard and brittle but on kneading becomes plastic. It has a bitter, spice-like taste and on warming has an aromatic odour. S. G. 1.04—1.07; M. P. 93—104°. It dissolves completely in alcohol only on boiling. It is employed in the preparation of varnishes, cements, and fumigating mixtures and as a drug.

An asphalt cement obtained by melting together pitch and asphalt is sometimes known as mastic.

Matches. A distinction is drawn between phosphorus or brimstone matches, which ignite when struck on any surface, and safety or Swedish matches,

which, containing no phosphorus themselves, can only be struck on specially prepared substances. A new class of matches has of late been added to these two, which although they contain no poisonous phosphorus or even white phosphorus, can still be struck on any surface.

Matches are made from the wood of pine, fir, and spruce, more rarely of willow, lime and aspen. Safety matches are almost always made from aspen, but some inferior kinds are made from poplar, lime, willow, and fir.

The wooden part of common phosphorus matches is generally made by machinery of special construction. The wood for safety matches is split and cut by the same machine. The machine tears off a strip, of the thickness required for the matches, these strips are then tied together and passed through the cutter, coming out in the form in which they are sold. Planed wooden strips cannot be used for safety matches, as this process presses the material which is then no longer sufficiently porous to absorb the paraffin. The wooden strips for the best matches are impregnated with a 1 % solution of ammonium phosphate to prevent smouldering. Coloured substances such as rhodamine or ponceau are added to the solution to stain the wood. The match wood after being cut and dried is then fixed into dipping frames, each match at about 1 cm from the next. If common sulphur matches are to be made, the frame is then dipped into sulphur, or if a better class of phosphorus or paraffin match is to be made into paraffin. One of these two processes is necessary that the wood may readily catch fire on being struck, the small flame given out by the head of the match not being sufficient to ignite the unprepared wood. The heads of common matches contain about 38 % of glue, gum or dextrine, about 20 % of white phosphorus, 38 % of chalk or zinc white as filling, to prevent too rapid burning and 4 % of Venetian turpentine.

The better kinds of phosphorus matches, for instance the Vulcan or Lucifer matches, contain 6—7 % of white phosphorus besides lead peroxide or lead nitrate. A special kind of phosphorus matches contains besides about 27 % glue and gum, also 6—7 % of phosphorus, about 36 % of potassium chlorate and about 30 % of filling (zinc white or powdered glass). To this class belong the paraffin, parlour and magenta matches.

The ignition mixture of safety matches consists of 15—16 % of glue and gum as adhesives, 45—55 % potassium chlorate, about 5 % of potassium chromate, about 5 % of ground sulphur and about 25—30 % of filling and colouring matter. Zinc white, powdered glass, infusorial earth, chalk, &c., are used as filling materials. Rhodamine is used as a red and *Caput mortuum* as a brown colouring matter. For yellow, no colour is taken, but potassium chromate and sulphur are used and in some cases barium chromate is also added. The friction surface on match boxes is made of about 23 % gum or glue as adhesive, about 53 % red (non-poisonous) phosphorus, 10 % antimony trisulphide and about 13 % lamp black or Cassel brown as filling and colouring material.

Except for unimportant variations, which are as a rule the trade secrets of the particular factories, all ignition mixtures for the heads of matches are made up in the above proportions. In the mixing of the materials, however there are certain rules to be observed as regards temperatures and solution of the adhesives. The mixing must be done very carefully and the mixture often requires re-grinding. The substance for the friction surface on the boxes must also be kept in just the right condition after being first mixed in proper proportions. The preparation of phosphorus ignition substances must always be carried out in special vessels which are air-tight.

It cannot be denied that the use of the so-called safety matches is combined with some inconvenience, since they only ignite on specially prepared surfaces. On the other hand however, common phosphorus matches are poisonous, so that their manufacture is now forbidden in several countries.

It may be taken for granted, that phosphorus matches will entirely disappear from the market in the course of a few years. This fact lends new importance to attempts made to produce a match free from white phosphorus, which may be struck on any surface. The experiments made were for a considerable time unsuccessful, and none of the many patented preparations, or those proposed, were found really practical. Even the mixture used by the French Monopoly Management of CAHEN and SEVERE, which consists of sesqui-sulphide of phosphorus, has many disadvantages, not only in manufacture but also in use. These disadvantages are gradually disappearing and matches are now made which are tolerably good, can be struck on any surface, and instead of being made of yellow phosphorus are prepared from mixtures of phosphorus sulphides. Compare PHOSPHORUS COMPOUNDS.

The head of the non-poisonous, Schwiening Triumph match, now often called "Reich"-Match contains besides red phosphorus and potassium chlorate, calcium plumbate. Compare No. 20 "LEAD COMPOUNDS".

These matches have, however, little prospect of becoming popular; in fact it is asserted they have been proved to be both dangerous and impracticable.

All the more important herefore, are the attempts to make a match, which will strike on any surface and yet contain no yellow phosphorus. According to Amer. Pat. 727758 non-poisonous matches are made by grinding together trisulphide of phosphorus and zinc oxide, adding potassium chlorate, iron oxide and powdered glass in certain proportions.

The Engl. Pat. 4009 (1903) makes use of compounds of phosphorus for making non-poisonous matches which ignite on any surface.

According to Germ. Pat. 153188 metallic sulpho-phosphorus compounds are used, i. e. hypo-thiophosphites and thiophosphites, e. g. zinc hypo-thiophosphite. These substances are prepared by mixing red phosphorus, sulphur, and metallic sulphides, particularly antimony sulphide, iron sulphide, copper sulphide and zinc sulphide in theoretical proportions, and gradually pouring the mixture into an iron boiler. The temperature is gradually raised to 450° and CO_2 is passed through the apparatus during the operation.

Germ. Pat. 157424 protects the preparation of an ignition mixture of sulpho-cupro-barium polythionate and KClO_3 . Copper salts are first treated with sulphites and then precipitated with Ba salts. The product is intimately mixed with sulphur and afterwards converted by strong pressure into the above-named substance. The compound is loose, can be easily powdered and made semi-liquid. The head made of this material lights better than SCHWIENINGS, though but not so well as matches made with yellow phosphorus. In match manufacture the so-called bright red phosphorus may, under certain circumstances, become more important than any of the above named mixtures which ignite on any surface. This peculiar modification of phosphorus which is obtained by heating yellow phosphorus in phosphorus tribromide is non-poisonous, and contains no arsenic even if this was present in the original material. It is perfectly soluble in H_2O , does not spontaneously ignite in the air, and readily undergoes chemical change, on account of its finely divided condition. Germ. Pat. 144456, which protects the use of bright red phosphorus in the manufacture of matches, remarks that 10% of this material can be mixed with potassium chlorate without danger of explosion, and that matches made from this substance ignite on any roughened surface.

According to Germ. Pat. 157382 the "Chemische Fabrik Griesheim Electron" makes use of an ignition mixture of phosphorus oxide, P_2O_5 , with KClO_3 and the other usual ingredients. The matches can be struck on smooth or rough surfaces. The sulphophosphite employed by this firm promises to become of great importance in the manufacture of matches. See "SULPHOPHOSPHITES". The compound keeps as well as red or bright red P, and is

much cheaper than the latter. It has the great advantage over the sulphur and phosphorus compounds of being quite unaffected by hot water, air or damp. The substance for the match-head is made of two mixtures, A and B. A, consists of 12 parts of sulphophosphite, 3 parts of zinc oxide, 4 parts of chalk and 18 parts of powdered glass, very finely ground and mixed to a thickish paste. B, is composed of 45 parts of potassium chlorate, 4 parts of gypsum, 15 parts of glue and 2 parts of gum Tragacanth. The gum is dissolved in hot water, then mixed with the other ingredients and very carefully ground. Finally the two mixtures are well stirred together. The preparation is much less dangerous than that of SCHWIENING's compound, in which the mixture containing the red phosphorus and part of the KClO_3 have to be reground together.

Germ. Pat. 163078 of the same firm protects the preparation of a non-poisonous ignition mixture containing P_2S_3 , P_3S_4 and P_2S_5 . The objection to the process lies in the fact that during the preparation the temperature must not exceed 30° , otherwise decomposition takes place.

Machines for manufacturing matches:

A. Roller, Berlin N. 20 (see front part advt.).

Mazute. The liquid residue from the distillation of Petroleum, which is used to an increasing extent for heating steam boilers. Its calorific power is almost double that of coal.

The burners used for liquid fuels are of three types:

1. Mechanical burners in which the oil is forced out in thin streams under great pressure.

2. Air burners in which the oil is fed into the furnace by means of air.

3. Steam burners in which the oil enters in fine streams, made partly in the burner and partly by mixing with air. The oil is forced into the furnace by steam pressure.

In Körting's mechanical burner the oil is forced in under a pressure of 4 atm. after having been warmed to 120° . In the second type of burner the oil must also be heated. The steam burners give larger flames. Several small burners give better results than one large burner. The streams of oil are usually directed against brickwork from which they fall into fire-clay-lined furnaces. For each burner of 50 H. P. an area of 400 square centimetres is required. The flames should not directly touch the boiler walls, and as a precaution against fire, the oil in the storage vessels should not be kept at a temperature above 65° .

The chief advantages in the use of liquid fuel are the absence of ashes, soot and clinkers, the smaller labour-charges and the simplicity of the firing. The disadvantages are the danger of fire due to defective storage, the high price of the burners and the noise caused by badly-constructed burners.

Mazute:

Willy Manger, Dresden, Germany.

Medicated soaps. This term includes all soap and soap-like mixtures which are used medicinally.

The officinal *Sapo medicatus* is made of equal parts of pure lard and olive oil, saponified with caustic soda in a prescribed manner.

Superfatted soaps find extended use for medical purposes. They consist of neutral soaps with 3 to 5 % excess of non-saponified fat or uncombined fatty acids.

The following are a few of the many preparations. According to Germ. Pat. 154548 and 157385, a good absorbent soap is made by mixing carefully

dried soap with vaseline and adding, if necessary, after warming, some substance such as sublimate, salicylic acid, benzoic acid, cinnamic acid or other drugs. The method can be applied to all substances which are set free by the action of water on the soap.

The Germ. Pat. 157737 protects the manufacture of soap containing zinc oxide; the Engl. Pat. 22580 (1903) of soaps with per-borates or per-carbonates.

The Engl. Pat. 9638 (1904) deals with the manufacture of the so-called acremnine soaps, which are used for preventing the poisonous effects of lead, copper, arsenic, and mercury. These are made by mixing the soaps with substances which evolve hydrogen sulphide or form sulphides when brought into contact with metals. Finally mention should be made of the ceramine soaps. These are mixtures of potassium and sodium soaps with balsam of Peru and oil of cinnamon. They are much used in cases of eczema on account of their antiseptic properties.

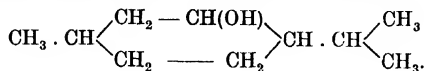
Compare also the articles on SOAPS, FORMALINE SOAP, METAL SOAPS and SPIRIT SOAP.

Melioform. A ruby-red transparent liquid containing 25 % formaldehyde and 15 % aluminium acetate. It is used as a disinfectant for the hands, for wounds, &c. but does not appear to have a very powerful action.

Melting points.

	°C		°C
Acetic acid	+ 17	Iodoform	+ 82
Alcohol (Ethyl alcohol) . .	— 130	Lead	+ 328
Aluminium	+ 625	Magnesium	+ 750
Ammonia	— 75	Menthol	+ 42
Aniline	— 8	Mercury	— 39
Anthracene	+ 213	Naphthalene	+ 79—80
Anthraquinone	+ 273	α -Naphthol	+ 94
Antimony	+ 432	β -Naphthol	+ 122
Antipyrine	+ 113	Nickel	+ 1600
Benzidine	+ 122	Nitroglycerine	+ 8—11
Benzoic acid	+ 121.4	Paraffin	+ 36—76
Benzene	+ 6	Phenol	+ 41
Bismuth	+ 269.2	Phosphorus, white	+ 44.2
Bromine	— 7.3	Pieric acid	+ 122.5
Bronze	+ 900	Platinum	+ 1775
Cadmium	+ 320	Potassium	+ 62.5
Camphor	+ 175	Pyrogallol	+ 115
Caoutchouc	+ 112	Resorcine	+ 110
Cobalt	+ 1400	Rape oil	— 3—4
Copper	+ 1082	Sulphur	+ 109
Chloralhydrate	+ 57	Sulphur dioxide	— 76
Chloroform	+ 7	Silver	+ 968
Diphenylamine	+ 54	Sodium	+ 96
Glass	+ 1000—1200	Stearine	+ 43—50
Gold	+ 1072	Tin	+ 231.7
Iodine	+ 114	Turpentine	— 10
Iron:		Wax, yellow	62.5
Cast iron, grey . . .	+ 1200	Water dist.	0
" " white	+ 1100	" Seawater	— 2.5
Steel	+ 82	Zinc	+ 417.6

Menthol. A terpene alcohol of the following constitution



It is the most important constituent of oil of peppermint (q. v.). To obtain it from this substance, the terpenes are removed by fractional distillation and the higher boiling fractions cooled and allowed to crystallize. According to Germ. Pat. 42458 peppermint oil may be treated with sodium in ether solution in order to increase the quantity of menthol. The terpene ketone, menthone, is by this method reduced to menthol, the sodium compound formed being decomposed with water.

Menthol forms colourless crystals M. P. 42°; B. P. 212°. It is largely used for the preparation of tooth- and mouth-washes.

Mercurization see "COTTON".

Mercury. Hg. (Hydrargyrum.) A. W. = 200.3. It is the only metal which is liquid at ordinary temperatures. It occurs here and there in the pure state, also as a silver amalgam, but principally as cinnabar (mercury blende) HgS. From the latter ore the mercury is obtained either by simply roasting the ore in a current of air in crucible, blast or reverberatory furnaces, in which the sulphur is oxidized at a red heat and both constituents of the ore volatilize — $\text{HgS} + \text{O}_2 = \text{Hg} + \text{SO}_2$ — or by decomposing the ore with iron or lime which combine with the sulphur while the mercury volatilizes. The latter process, which is carried out in crucible furnaces, is expressed by the following equation, according as the decomposition is carried out with Fe or CaO: $\text{HgS} + \text{Fe} = \text{Hg} + \text{FeS}$, or $4 \text{HgS} + 4 \text{CaO} = 4 \text{Hg} + 3 \text{CaS} + \text{CaSO}_4$. The volatilized Hg is condensed either in brick chambers or better in condensing arrangements (clay and iron pipes immersed in water); glass condensers have also been used.

H. BECKER has proposed to obtain Hg in the electric furnace by constantly feeding the latter with a mixture of lime and cinnabar and collecting the Hg in cooled receivers.

The different wet methods for the production of Hg have been only partially successful. On the other hand the electrolytical process, by which the cinnabar is easily decomposed at the anode and Hg deposited at the cathode by using a solution of NaCl or HCl, promises to become of technical importance; for seeing that the E. M. F. of the bath is 1 volt the amount of carbon used to obtain 1 kg of Hg per hour amounts to approx. 1.08 kg, and besides this the injurious action of Hg vapours in the dry process is completely avoided.

The mercury thus obtained is freed from mechanical impurities by pressing it through bags of leather or linen. Frequently it is subjected to another distillation, but in this case small amounts of other metals also distil over. In order to remove these the mercury is allowed to trickle in a fine stream through a long column of dilute HNO_3 which dissolves the other metals more readily than Hg; it is then washed with water and dried. Mercury is brought into commerce in wrought iron flasks which hold 34.5 ko in Almaden (Spain) and in Mexico and 34.7 ko in California.

It is a silver-white glittering metal which is not acted upon by moist air, and evaporates slowly at ordinary temperatures — much more readily when moderately heated. S. G. 13.59; M. P. — 39.4°. B. P. 357.3°. Near the boiling point it is converted into red HgO which decomposes again at a higher temperature (500°) into Hg and O. The greatest quantity of Hg is used in the production of gold and silver by the amalgamation process. It is further used for filling barometers, thermometers, manometers, mercury air pumps, &c.;

for the manufacture of "fulminates", artificial cinnabar, coating mirrors, &c.

At the ordinary temperature or very little above it the following metals combine directly with Hg:— K, Na, Mg, Sn, Zn, Pb, Bi, Ag, Au, Al, Sb. Cadmium dissolves readily in heated Hg, and in this way an alloy is obtained which only slowly solidifies but then becomes very hard; this — like a similar alloy of 1 part Cd and 2 parts Sn with Hg — finds employment as a filling for teeth.

Gold amalgam is used for fire-gilding metals. See "GOLD-PLATING". Tin amalgam is used for coating mirrors and contains $\frac{1}{4}$ to $\frac{1}{8}$ Sn, and is prepared by pouring Hg over tin-foil.

It is well known that the zinc electrodes of galvanic elements are superficially amalgamated by rubbing them with Hg, because the elements when treated in this way give a more uniform current and at the same time last longer.

As a coating for the frictional electric machine the KIENMEYER's amalgam is used; this consists of 2 parts Hg, 1 part Sn and 1 part Zn: It is prepared by rubbing together fine filings of Zn and Sn (free from oxide) with Hg in a heated iron mortar.

The melting point of readily fusible Bi and Cd alloys is lowered still further by the addition of Hg. Thus an alloy of 45 parts Bi, 17 parts Pb, 20 parts Sn and 10 parts Hg, which melts at 70° C and becomes fairly hard on solidifying, is used for injecting into anatomical preparations.

As a metallic cement a solution of cadmium amalgam is used. It can be prepared by dissolving cadmium amalgam (26 parts Cd and 74 parts Hg) in a slight excess of Hg. The mass is at first, when moderately heated, as soft as wax and is workable, but gradually becomes very hard.

Sodium amalgam is frequently used for the reduction of readily decomposable substances by nascent H. It is prepared by placing Hg in an iron mortar and pressing small pieces of Na into the mercury with the pestle; a small flash occurs and a small quantity of Hg is volatilized, and on this account the operation must be carried out in a draught chamber. According to the amount of mercury present the amalgam is liquid or solid. According to the Amer. Pat. 689926 sodium amalgam is prepared by heating paraffin to 130°, adding one part of Na and heating further; after the sodium melts, 53 parts of Hg are added. The paraffin is then poured off and the amalgam stirred while cooling. The greater amount of sodium amalgam is now prepared by the electrolysis of sodium chloride using Hg as the cathode; see the paragraph on mercury process in the article "CHLORINE ALKALI PROCESS, ELECTROLYTICAL". The other amalgams are now obtained in the same way electrolytically. The Germ. Pat. 148044 protects an arrangement for washing the alkali amalgam electrolytically obtained.

Mercury alloys (amalgams). Mercury forms alloys directly with most metals; with others, for which Hg has only very little affinity (e. g. Fe) the combination can be brought about by treating the very finely divided metal with mercury solutions. Many amalgams are at first liquid and only on standing for some time do the true alloys — which are in stoichiometric proportions — separate in the solid, crystalline state.

Mercury colours. The only one now used is cinnabar HgS (Chinese red, patent red, vermilion). It occurs as a mineral, but for use as a paint it is always prepared artificially; it can be prepared either by wet or by dry methods.

In the dry method 540 parts Hg are rubbed together with 75 parts S and the resulting black mercury sulphide sublimed from pear shaped vessels of cast iron with clay covers, to which earthen receivers are attached in order to collect the S which distils off. The cinnabar settles as a dark red crystalline

mass which is ground with water to prevent it from turning to dust, and then heated with a solution of potash to remove the mechanically mixed sulphur. The purified cinnabar is finally carefully washed, dried in dishes and ground to a very fine powder. The preparation of the genuine Chinese cinnabar, which on account of its extraordinary beauty costs five times as much as the European product is not known in detail.

There are several different processes for manufacturing cinnabar by the wet method. In one method, e. g., 5 parts Hg are rubbed together with 1 part sulphur to a grey powder and the mixture heated to 45° C with strong potassium hydroxide (45–50° Bé) until the powder becomes bright red. A similar process consists in rubbing 100 parts Hg with 38 parts S and heating the mixture in dilute KOH to 45°; after about eight hours the mass begins to turn red and the mixture is allowed, after the tone has become fiery red, to cool gradually. It is then poured into cold water, washed, and dried. Again, according to another process a HgCl_2 solution is precipitated with NH_3 and the resulting white precipitate of HgClNH_2 is treated for a long time at 45–50° C with a solution of S in ammonium sulphide. After the precipitate has turned red it is treated with KOH, washed, and dried.

The beautiful red colour of cinnabar is the brighter the more finely it is ground. It is adulterated by the addition of iron oxide, heavy spar, gypsum, minium, &c. It would be used to a greater extent in painting if it did not gradually turn pale and lose its colour.

Mercury compounds.

1. MERCUROUS CHLORIDE (Calomel). Hg_2Cl_2 . It is prepared by heating a mixture of 4 parts HgCl_2 with 3 parts Hg in a covered iron vessel until the grey mass turns white. Then a large dish (on a large scale the bottom half of a carboy is cemented on to the edge of the vessel) is placed on the vessel which is strongly heated until the calomel has completely sublimed. It is obtained by the wet method by precipitating a solution of $\text{Hg}_2(\text{NO}_3)_2$ with NaCl or by passing SO_2 into a HgCl_2 solution. Hg_2Cl_2 forms a colourless crystalline (as a powder, yellowish) mass, which is tasteless and odourless, almost insoluble in H_2O and dilute acids. It is decomposed by boiling H_2O , also by repeated sublimation; Hg is liberated when it is exposed to light. It is used in porcelain painting (for mixing with Au), for preparing bengal lights, and as a medicament; for the latter purpose it must be carefully washed to remove the HgCl_2 . See article "CALOMEL OIL".

2. MERCURIC CHLORIDE (Corrosive sublimate). HgCl_2 . It is obtained by subliming in clay crucibles on a sand bath a mixture of HgSO_4 and NaCl to which a small amount of MnO_2 is added. It sublimes as a white crystalline mass. It can also be prepared by a wet method either by dissolving Hg in aqua regia, or HgO in hydrochloric acid, and evaporating the solution. It has a metallic taste, acts as a strong corrosive, and is very poisonous. Soluble in H_2O , alcohol, and ether. 100 parts H_2O dissolve (at 20°) 7.39 parts, at 50° 11.34 parts, at 100° 54 parts HgCl_2 . It is used for preserving railway sleepers, animal tissues, for etching steel, for the manufacture of aniline red and mercury preparations, in cotton printing, and in medicine as a strong antiseptic.

3. MERCURY NITRATES.

a) MERCUROUS NITRATE. $\text{Hg}_2(\text{NO}_3)_2$. It is prepared by allowing 1 part Hg to stand at ordinary temperature with 1 part of not too concentrated HNO_3 . It crystallises with 2 mol. H_2O and is dissolved unaltered by water but is decomposed by a large amount of H_2O with precipitation of a basic salt. Very corrosive, highly poisonous, it colours the skin purple red turning to black in the light.

b) MERCURIC NITRATE. $\text{Hg}(\text{NO}_3)_2$. Obtained by boiling Hg with excess of HNO_3 or by dissolving HgO in HNO_3 . On evaporating the solution salts

containing different amounts of water of crystallisation are obtained. They all readily decompose with H_2O with formation of basic salts. Very poisonous and corrosive.

4. MERCURIC OXIDE (red oxide of Hg; red precipitate). HgO . It is prepared by heating a mixture of equal mol. $Hg(NO_3)_2$ and Hg. It forms a brick red scaly crystalline powder soluble to a slight extent in H_2O , corrosive, and very poisonous. By pouring a solution of $HgCl_2$ into boiling NaOH mercuric oxide may be obtained as an orange red powder. It turns black in the light with separation of Hg. It is used in porcelain painting, in medicine, for the preparation of other Hg compounds, and as a paint for ships (to prevent plants and animals from settling on them).

5. MERCURY SULPHATES. MERCUROUS SULPHATE Hg_2SO_4 is obtained as a sparingly soluble crystalline precipitate by heating excess of Hg with concentrated H_2SO_4 . The mercuric sulphate is more important and can be prepared from Hg or HgO by heating with excess of concentrated H_2SO_4 ; it is termed amalgamating salt. On being treated with a large amount of H_2O it forms basic mercuric sulphate (*turpenthum minerale*) $HgSO_4 \cdot 2 HgO$, a citron yellow sparingly soluble powder.

6. MERCURIC SULPHIDE see "MERCURY COLOURS".

7. MERCURY AMMONIUM CHLORIDE (white precipitate). NH_2HgCl . It is obtained as a white powder insoluble in H_2O and alcohol by precipitating a $HgCl_2$ solution with NH_3 . It is used for the preparation of cinnabar (see "MERCURY COLOURS"), and also in medicine.

8. MERCURY FULMINEATE see "FULMINATES".

Mercury-Preparations:

Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Mercury vapour lamp. A mercury lamp consists of a long glass tube with a high vacuum with two electrodes fused through the glass: in the tube is a small amount of mercury. In order to light the lamp the vacuum is first overcome either by sending a current of high E. M. F. through it, or — which is more convenient and usual — the tube is inclined so that the mercury spreads out and forms a long thread-like connection between the two electrodes. Once the current passes through the tube the high current at first used can be reduced to the ordinary strength, and the tube may then be returned to its original upright position. The current then passes continuously through the tube and the mercury vapour glows strongly and in doing so emits an intense bluish-white light. The best appears to be the improved mercury vapour lamp of the Copper-Hewitt Electric Company; the tube hangs slanting and is movable about a horizontal axis but so balanced that it always returns to the normal slanting position. To light the lamp a small chain attached to the lamp is pulled (after the current has been turned on) until the tube is in a horizontal position which causes the mercury to make contact between the two electrodes. The chain is then loosed, the lamp returns to its normal position, the Hg column breaks, and the lamp lights.

Mercury vapour lamps can be constructed for different E. M. F. of 40 to 50 volts which are arranged two together in a current of 100—125 volts, just like the common arc lamps which are also usually placed two together. Such lamps are from 50—60 cm long; lamps for 100—110 volts must however, have, a length of at least 1 m which makes them very inconvenient.

The mercury lamps become very hot when in use and the danger due to breakage is considerable on account of the poisonous properties of mercury vapour. On this account HERÆUS has constructed mercury vapour lamps of quartz glass seeing that quartz glass is not sensitive to differences of temperature. For ordinary illuminating purposes, however, such a lamp cannot

be used because the quartz glass allows the ultraviolet rays — which are otherwise held back by ordinary glass — to pass through, and these rays (in which the Hg vapour lamp is very rich) have an extraordinarily strong physiological action, causing burns, inflammation of the retina, &c. The importance of this lamp lies in its scientific and medical applications.

Seeing that the ultraviolet rays have been used with good result for the treatment of skin diseases experiments have been made with a view of constructing a lamp similar to that of HERÆUS but in which the costly quartz glass is replaced. Such a lamp is SCHOTT's Uviollamp; the tubes consist of a special glass which allows a large percentage of the ultra violet rays to pass through freely.

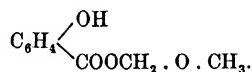
The ordinary mercury vapour lamps would be more widely used for illuminating purposes if the light did not possess such an unpleasant cold bluish-white tone. Many attempts have been made to remove this drawback by means of coloured globes. In the so-called orthochromatic lamp a mercury vapour lamp is combined in one globe with several common carbon filament lamps; the bluish-white mercury light and the reddish carbon light form together a very pleasant white illuminant.

The mercury vapour lamp is becoming of increasing importance for photographic studios on account of its richness in chemically active rays.

Mergol. Mercury cholate $(C_{24}H_{39}O_5)_2Hg$. Yellowish-white powder insoluble in water. Prescribed in capsules with tannin and egg albumen in syphilis.

Meriodine (Mercury sozoiodol). Prescribed in syphilis as tablets, each one containing 0.005 g Hg.

Mesotan = Methyloxymethyl ester of salicylic acid.



Clear, slightly aromatic oily liquid S. G. 1.2 at 15° C. Slightly soluble in H_2O , and soluble in all proportions in alcohol, ether, benzene, chloroform, and fatty oils.

Mixed with an equal amount of olive oil it is used as an ointment in rheumatic diseases. It is not used internally.

Metachrome mordants see "CHROME MORDANTS".

Metakaline. Solid disinfectant. According to composition a cresol soap preparation, consisting of 80 % of a crystallized double compound of potassium m-cresolate + 3 mol. m-cresol with 20 % soap.

Metakaline therefore contains 73.54 % pure m-cresol, the most effective bacteriologically and at the same time least poisonous phenol. In contrast to all other cresol disinfectants it is not a mixture but a definite chemical compound, as it contains no isomers or homologues of m-cresols. Its power of disinfecting is very considerable.

The preparation of metakaline was rendered possible when the double compound of potassium m-cresolate and 3 mol. m-cresol was discovered (Germ. Pat. 156761).

It is sold in the form of tablets.

Metals.

	Specific gravity	Melting point		Specific gravity	Melting point
Aluminium	2.67	660°	Magnesium	1.74	700° to 800°
Antimony	6.71	425°	Manganese	up to 8.0	1900°
Barium	4.00		Mercury	13.596	— 42°
Bismuth	9.82	270°	Nickel	8.9	1500°
Cadmium	8.65	315°	Osmium	22.45	2500°
Calcium	1.58	at red heat	Palladium	11.4	1700°
Chromium	6.8	over 2000°	Platinum	21.5	1800°
Cobalt	8.5		Potassium	0.865	62° .5
Copper	8.95	109°	Rubidium	1.52	38° .5
Gold	19.265	1064°	Silver	10.468	1000°
Iridium	22.4		Sodium	0.974	95° .6
Iron, pure	7.85 to 7.88	1800°	Steel	7.6 to 7.8	1300° to 1400°
Iron, wrought	7.79 to 7.85	1500° to 1600°	Strontium	2.50	at red heat
Iron, cast (white)	7.58 to 7.73	1050°	Thallium	11.8	290°
Iron, cast (grey)	7.03 to 7.13	1200°	Tin	7.30	235°
Lanthanum	6.05		Zinc	6.91	423°
Lead	11.367	334°	Zirconium	4.15	2000°
Lithium	0.594	180°			

Hardness (Lead = 1), Aluminium 17.3, Bismuth 3.3, Cadmium 6.9, Copper 19.3, Gold 10.7, Iron, cast (grey) 64.0, Iron, wrought 60.7, Platinum 24.0, Silver 13.3, Tin 1.7, Zinc 11.7.

Metal colouring. To this class of colouring belong oxidizing, platinizing, browning, bronzing, &c. Almost all metals and their alloys can be coloured, but silver, copper and copper alloys are those most usually treated, although iron is also very frequently coloured in other ways than the usual browning (of gun barrels) &c.

1. **COLOURING SILVER (OXIDISING).** "Old silver" is produced by converting the surface into silver sulphide. BUCHNER ("Die Metallfärbungen") and STEINBACH and BUCHNER ("Die galvanischen Metallniederschläge", Berlin 1896) recommend the following solutions for the above purpose.

	I grammes	II grammes	III grammes
Potassium sulphide	1.0	—	5.0
Ammonium sulphide	—	4.0	—
Ammonium chloride	—	8.0	—
Ammonium carbonate	—	—	10.0
Water	1 kg	1 kg	1 kg
Applied	at 100° C	at 70—80° C	Cold

The colour will be first yellow brown and later dark blue black. After treatment the article is brushed with H₂O and pumice stone or with powdered cream of tartar. If a fine black is wished, the article is first dipped in a solution of mercurous nitrate rinsed in water and treated with one of the sulphide solutions.

2. **BROWNING COPPER.** The article is rubbed with powdered blood stone, with antimony sulphide or with a mixture of both, in a dry state with a soft leather. The sulphide of antimony gives a blackish brown, the iron oxide a pure brown tint. The article can also be warmed as hot as the hand can

hold and rubbed with a mixture consisting of the following:— 10 g potassium nitrate, 10 g NaCl, 20 g ammonium chloride, 20 g ammonium acetate, and 60 ccm glacial acetic acid dissolved in one litre of H_2O . Another method is to dip the article, which must first be well cleaned, into boiling water and then into the following bath. 15 g potassium chlorate 7 g potassium nitrate, 20 g sodium sulphate 20 g ammonium chloride, and 400 ccm of glacial acetic acid in 1 litre of water. The following solution is also strongly recommended (this must also be used at boiling point, and the article must previously be heated in warm water):— 5 g of neutral copper acetate and 2.5 g ammonium chloride are dissolved in 1 litre of water. The solution is evaporated to a quarter of a litre, when 30 ccm glacial acetic acid are added and the solution boiled again for 5 minutes. After this the slight sediment is filtered off and the filtrate diluted to 4 litres. After any of these operations the article should be treated with a scratch brush.

3. TO COLOUR COPPER RED. According to Germ. Pat. 149566 the articles are dipped into a bath of molten potassium nitrite at red heat. The colour passes from yellow-brown to bright-red. Or the article can be heated to red heat and sprinkled with the nitrite. The heating must be continuous and the object constantly turned. When the desired tint is obtained it is allowed to cool and the excess of nitrite washed off with water. According to Germ. Pat. 152586 the copper article is heated to a cherry-red heat, then cooled to black-heat and suddenly dipped into a solution of ferric chloride (15 g Fe_2Cl_6 in 1 litre of distilled water). By this means any tint from red to violet can be obtained.

Mention should also be made here of Germ. Pat. 153308 according to which a red colour, the so-called blood bronze, can be obtained by heating the copper article to red heat. This covers the article with a coating of cuprous oxide below and cupric oxide on the surface. After cooling the article is polished on a wheel till the black CuO coating is rubbed away and the burnished red Cu_2O coating appears. According to Germ. Pat. 163067, highly polished copper articles are galvanized with As or Sb. The bath is prepared by dissolving salts of antimony or arsenic in KCN solution and adding this to a solution of Fe_2Cl_6 till the precipitate re-dissolves. An iron plate is used as anode. The coated article after being galvanized is heated to cherry-red and then again polished. The colour obtained is red to violet, all shades of which are durable and not affected by external agencies.

4. TO BLACKEN COPPER. A solution of ammonium sulphide is used for this purpose. A little sulphur should be added to the liquid, which is then applied to the heated article with rags. This operation is repeated several times and the article is finally well rubbed with a little olive oil. The following black stain is recommended by the Physik.-Techn. Reichsanstalt. In 1 litre of H_2O 300 g of cupric nitrate and 12 g of silver nitrate are dissolved. If the Cu salt crystallizes out, more water must be added. The articles are treated for 5–10 minutes in HCl (1 litre of H_2O + 1 litre of HCl), and are then dipped in the copper solution at $45^\circ C$, or they can be brushed with the solution instead of being dipped. After drying which must take place very slowly, they will appear green, but will turn deep black on heating over a coal fire. After cooling the articles are treated with a scratch brush on are well rubbed with oil.

5. TO COVER COPPER WITH PATINA. The patina will only look well if it is developed very slowly. First the brown tone must be obtained by treating the article with a very dilute solution of ammonium sulphide. The colour must on no account be dark. The following solution is then painted or brushed on to the dried article. 4 g of potassium binoxalate, 8 g of ammonium chloride, 8 g of salt and 50 g glacial acetic acid in 1 litre of H_2O . (Compare also the instructions for coating brass with patina, No. 8 of this article.) The process

must be repeated several times, letting the article become perfectly dry each time without rinsing, before repeating. If a patina of a blue green shade is desired the article should be painted over before the last coating with a solution of ammonium carbonate. The dried patina coating should be finally treated with a soft clean brush or with a scratch brush. Of late it has become more usual to carry out this operation of covering copper with patina by electrolysis. Setlik states that if copper, brass or bronze objects are hung as anodes in a 4 % solution of ammonia with a current of 2 volt a beautiful patina will appear rather rapidly, the colour being first red, and if left longer changing to green. According to Germ. Pat. 93543 a weak solution of carbonates should be used as electrolyte, the current being regulated to 1 amp. per 1 sq. m surface and 3 volt. The process with ammonia appears however to be a better one.

6. **BROWNING BRASS.** The article is dipped in a solution of 10 g of potassium permanganate, 50 g glacial acetic acid and 5 g of HCl in 1 litre of H_2O . A light brown is obtained by treatment with the following solution. 20 g of As_2O_3 and 20 g of K_2CO_3 are boiled with 200 g of H_2O till completely dissolved. The solution is then diluted to 2000 ccm, and 500 g of yellow ammonium sulphide added. The articles should be completely immersed, quickly rinsed in H_2O , rubbed dry and varnished.

Articles can also be browned by brushing while dry in the way given under 2 (BROWNING COPPER), that is with oxide of iron, antimony sulphide and arsenic sulphide. By a suitable mixture of these substances and treatment for a longer for shorter time, shades ranging from light brown to black can be obtained.

7. **TO COLOUR BRASS BLACK.** The best plan is to treat the articles with the following solution of copper oxide in ammonia which acts even when cold. 1 litre of ammonia, S. G. 0.96 is placed in a flask with 125 g of $CuCO_3$, well shaken until the latter is almost entirely dissolved, and 500 ccm water are then added. The solution keeps well if the bottle is properly stoppered and needs only to be freshened from time to time with a little NH_3 . The objects when placed in this solution will after a time become black. If the tint is not yet satisfactory, the article is redipped in the solution a second time. The articles must be well cleaned before treatment and should not be touched with the hands as this causes spots. After the oxidation is complete, the article should be well rinsed and after being thoroughly dried it should be covered with a black varnish. Brass objects can also be made black with the stain recommended for colouring copper black in No. 4 of this article.

8. **TO COVER BRASS AND BRONZE WITH PATINA.** The process is very similar to the one described for the treatment of copper. The article is first browned with liver of sulphur to a light shade and then dipped in the solution given under No. 4 COVERING COPPER WITH PATINA, or in the following one which is also recommended. 10 g of ammonium chloride, 10 g of cream of tartar, 45 g of salt, 80 g of copper nitrate and 60 ccm of glacial acetic acid are dissolved in 1 litre of H_2O . The rest of the treatment is precisely the same as that given above for copper. The solution just mentioned, can also be used for copper. It must be once more repeated that a good coating of patina can only be obtained slowly. Also the electrolytical process, given in No. 5, using a NH_4Cl electrolyte can be used with great advantage for covering brass and bronze with patina.

9. **TO COLOUR IRON AND STEEL BLACK.** The oxidized articles of iron which are now so popular are produced by dipping the clean article in boiling water and then immediately afterwards into a solution of 1 part of potassium bichromate in 10 parts of H_2O . The article is then dried in the air and heated over an open smokeless coal fire. In this way a black to brown colour is obtained. By repeating the whole process several times and heating intensely a blue black and even a deep, jet black tint can be obtained.

10) **BROWNING IRON AND STEEL.** This process is mostly used for fire arms and especially gun barrels. A solution of 125 g of copper sulphate, 160 ccm of HNO_3 , 1 litre of H_2O and 16 ccm of alcohol is painted on in thin coatings and allowed to stand for 3—4 hours. The slight rust then formed is brushed off with a bristle brush. The process is repeated about 6 times in the course of three days, the traces of acid are then washed off with boiling H_2O , the article is dried, smoothed with a polishing wood and finally well rubbed with oil. The procedure is similar when a browning mixture consisting of 1 litre antimony chloride with $\frac{1}{4}$ of a litre of olive oil is used. The emulsion, which must be well shaken, is painted on to the slightly warmed gun barrel, and the article put aside for 24 hours. After this time has elapsed the gun barrel is oiled and carefully rubbed. By repeating this treatment a fine even brown will appear in about 8 days time, when the article should be finally well polished with a scratch brush or a polishing steel.

Metal polishes, grinding and cleaning media. These are emery, Vienna lime, chalk, pumice stone, tin ashes, stearin oil (polish oil), English red, and many other preparations, consisting of the materials mentioned and others. See also "POLISHING AND GRINDING MATERIALS".

Metal soaps. Salts of the heavy metals and fatty acids are usually described by this term. The Germ. Pat. 148794 deals with the simple and economical preparation of solutions of metal soaps for coating, impregnation, and disinfecting purposes. The patent deals more especially with the saponifications of the oleic and colophonic acid salts of Cu, Fe, Pb, Mn, Co, Ni, Al, Zn, Mg, Sn, Sb, Ag, and Hg. The process is essentially based on the employment of phenols, such as carbolic acid and cresols (more especially the crude commercial carbolic acid) with the addition of alkali or ammonium soaps, as solvents of the metallic soaps. In this way solutions of metal soaps in phenols are obtained, which may or may not be soluble in water. To produce for instance a copper soap solution, an aqueous solution of copper sulphate in certain proportions is added to a solution of a crude cresol potassium soap, which contains 5 parts of soluble crude cresol in soda lye, to 3—5 parts of a potassium fatty acid soap, soluble in water: In this case, the copper soap does not separate as a precipitate, as it does when copper sulphate is added to an aqueous alkali soap solution, but passes directly into the cresol, while the potassium sulphate simultaneously formed goes into solution, or is partially precipitated. Two clear layers are formed which can be easily separated. After the upper, viscid, green, cresol layer is removed, it will be found to contain a solution of copper soap uncombined with the potassium sulphate. It is thus formed without the necessity (as in the usual methods), of a tedious process of washing to remove the alkali salts which appear simultaneously with the copper soap.

According as the soap is entirely or partially converted into the metal soap, insoluble or soluble products, are obtained. Oleic or colophonic acid can also be dissolved in phenol &c. and treated either with metallic compounds alone or with a mixture of these and the alkalies, the latter being used to combine with the acid or to help to form the soap. Again metal soaps can be mixed with phenols or with phenol and alkali soaps. According to the Supplement to Germ. Pat. 148795, the phenol described in the original patent can be replaced entirely or partially by tar, or petroleum hydrocarbons.

Metal soaps are obtained in solution, if the mixture is treated with sufficient quantities of alkali or ammonium soap. The metal soaps are also rendered soluble in water if treated with hydrocarbons or hydrocarbons and phenols. The products obtained, especially when light hydrocarbons such as petroleum ether, benzene, petroleum, benzene or mixtures of these substances

with phenols have been used, are, when employed in a soluble form, excellent destroyers of underground vermin and harmful creatures. The process of manufacture for metal soap solutions is analogous to that given in the original patent.

Metal casting of all kinds:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 8b, (see advts.).

Metal tubing see "HOSE".

Metallic coverings, platings see under "ELECTRO PLATING", "METAL COLOURING", "PLATING", "LEAD-", "GOLD-", "COPPER-", "BRASS-", "NICKEL-", "PLATINUM-", "SILVER-", "STEEL-", "ZINC-" and "TIN-PLATING".

Metalline see "COBALT ALLOYS".

Methanal see „FORMALDEHYDE“.

Methylacetanilide see „EXALGINE“.

Methyl alcohol. On a commercial scale methyl alcohol is prepared from the crude pyroligneous acid (q. v.) of wood distillation (q. v.). The crude pyroligneous acid is distilled in copper retorts with three *Pistorius* basins placed one above the other; the whole of the methyl alcohol has passed when the S. G. of the distillate leaving the cooler rises from 0.9 to 1. The crude wood spirit thus obtained, a greenish yellow liquid of disagreeable smell, is mixed with about 2 % of lime to remove the many impurities, and after standing for several hours is distilled in a rectifier with six *Pistorius* basins (the apparatus resembles that used in rectifying spirits, see "RECTIFICATION"). The colourless distillate (S. G. 0.816) becomes brown upon standing and turns milky when mixed with water. It is mixed with H₂O until the S. G. is 0.935, and left to stand for several days. The liquid is removed from the oily layer, mixed with 2 % of lime and redistilled; the distillate finally is mixed with 0.1—0.2 % H₂SO₄ and rectified, the fraction passing between 64 and 66° C being collected.

Wood spirit thus rectified always contains acetone, an impurity which is objectionable for many purposes. Various methods of removing it have been proposed. Pure methyl alcohol is generally prepared by first forming a methyl ester. This is separated from the liquid, decomposed by KOH, and pure methyl alcohol then obtained by distillation. E. g. methyl oxalate is produced from pure wood spirits, concentrated H₂SO₄ and potassium oxalate, or wood spirit is treated with sodium formate and HCl to give methyl formate, after which the method indicated above is followed. Methyl benzoate has also been used for this purpose.

According to the Germ. Pat. 138442 methyl alcohol is obtained by electrolysis of sodium acetate and sodium perchlorate. The Amer. Pat. 774824 and the French Pat. 352687 deal with the preparation of methyl alcohol from methane. This gas (according to the former patent) is conducted over heated metallic oxides (e. g. Fe₂O₃) while the other patent uses a solution of hydrogen peroxide as oxidizing agent, through which the methane is passed.

Pure methyl alcohol is a colourless liquid of faint smell, burning with a colourless flame; S. G. (at 15°) 0.7984; B. P. 66° C. It mixes in any proportion with H₂O, alcohol, ether, and chloroform. Wood spirit is used in the preparation of varnishes and polishes, to denature spirits. Pure methyl alcohol containing no acetone is used in the manufacture of coal-tar dyestuffs.

TEST. The water is determined from the specific gravity, using the following table by DITTMAR and FAWSITT, referred to a temperature of 15.56°.

Weight % Methyl- alcohol	S. G. at 15.56°	Weight % Methyl- alcohol	S. G. at 15.56°	Weight % Methyl- alcohol	S. G. at 15.56°	Weight % Methyl- alcohol	S. G. at 15.56°
1	0.99729	38	0.94055	63	0.89133	82	0.84521
2	0.99554	40	0.93697	64	0.88905	83	0.84262
4	0.99214	42	0.93335	65	0.88676	84	0.84001
6	0.98893	44	0.92975	66	0.88443	85	0.83738
8	0.98569	46	0.92610	67	0.88208	86	0.83473
10	0.98262	48	0.92237	68	0.87970	87	0.83207
12	0.97962	50	0.91855	69	0.87714	88	0.82938
14	0.97668	51	0.91661	70	0.87487	89	0.82668
16	0.97379	52	0.91465	71	0.87262	90	0.82396
18	0.97039	53	0.91267	72	0.87021	91	0.82123
20	0.96808	54	0.91066	73	0.86779	92	0.81849
22	0.96524	55	0.90863	74	0.86535	93	0.81572
24	0.96238	56	0.90657	75	0.86290	94	0.81293
26	0.95949	57	0.90450	76	0.86042	95	0.81013
28	0.95655	58	0.90239	77	0.85793	96	0.80731
30	0.95355	59	0.90026	78	0.85542	97	0.80448
32	0.95053	60	0.89789	79	0.85290	98	0.80164
34	0.94732	61	0.89598	80	0.85035	99	0.79876
36	0.94399	62	0.89358	81	0.84779	100	0.79589

For chemically pure methyl alcohol the following holds. 1. Non volatile substances: When 30 ccm are evaporated on the water bath there should be no weighable residue. 2. Free acids are tested by blue litmus which should not become red. 3. Ethyl alcohol. Methyl alcohol is heated with H_2SO_4 diluted with water and distilled. The distillate is treated with KMnO_4 , then with H_2SO_4 and finally with $\text{Na}_2\text{S}_2\text{O}_3$. When dilute fuchsine solution is added it should not turn violet. 4. Aldehyde. A mixture of methyl alcohol with concentrated caustic soda solution should remain colourless. 5. Acetone. When 10 ccm methyl alcohol are mixed with caustic soda and an aqueous solution of iodine in potassium iodide no clouding due to iodoform should take place even after standing some time. 6. Emphyreumatic substances are best recognized by their smell after rubbing a drop of methyl alcohol between the hands. 7. Permanganate test: When 10 ccm methyl alcohol are mixed with 2 drops potassium permanganate solution (1 : 100) the ensuing red colour should not disappear in less than 10 minutes (at 15°C).

When the exact contents of methyl alcohol in the material is to be determined the method of KRAEMER (an improvement on KRELL's method) is used; it is founded on the fact that methyl alcohol when treated with phosphorus triiodide is transformed quantitatively into methyl iodide, while the impurities are not affected. The process is carried out as follows: 30 g phosphorus triiodide PI_3 are placed in a small retort of about 60 ccm capacity. The retort is connected with a reflux condenser and 10 ccm methyl alcohol allowed to run in drop by drop through a dropping funnel; then 10 ccm of a solution of one part iodine in one part hydriodic acid (S. G. 1.7) are added. After a little shaking the solution is cooled and connected with a condenser (which must be efficient because of the great volatility of the methyl iodide). Distillation on the water-bath follows, a graduated cylinder containing a little water acting as receiver. After distillation the condenser tube is rinsed with cold water, the distillate well shaken, and the amount of separated methyl iodide determined at 15°C . According to KRELL, 5 ccm pure methyl alcohol give 7.19 ccm CH_3I at 15° so that knowing the S. G. of methyl alcohol its percentage may be calculated from the amount of methyl iodide found.

Besides chemically pure methyl alcohol other kinds are sold which will not stand the tests given above. For these products, the makers guarantee by agreement the following properties: 1. Methylalcohol:— S. G. should not

be less than 0.7995. 2. Not more than 0.7 % acetone should be found by KRAEMER's method. 3. At least 95 % of the methyl alcohol should distil within one degree centigrade. 4. The alcohol mixed with twice the amount of 66 % sulphuric acid should not become darker than pale-yellow. 5. 1 ccm of a solution of 1 g potassium permanganate per liter should not be instantly rendered colourless by 5 ccm of the alcohol. 6. 25 ccm with 1 ccm bromine solution, as prescribed by the German Customs for the examination of wood spirit intended for denaturing (1 part bromine in 80 parts 50 % acetic acid) should remain yellow. 7. The alcohol mixed with any quantity of caustic soda solution must remain colourless.

KRAEMER's method of determining acetone is based upon the fact, that acetone is converted into iodoform quantitatively by iodine in presence of alkalies, while methyl alcohol and other impurities present in wood spirits do not give this substance. The method is as follows: 10 ccm 2 N NaOH solution are placed in a 50 ccm mixing cylinder with glass stopper, and then 1 ccm of the substance under examination, and after shaking well 5 ccm 2 N iodine solution. After standing for a short time, 10 ccm ether free from alcohol are added and the shaking is repeated. The volume of the separated ether is read, an aliquot part removed with a pipette (about 5 ccm) and allowed to evaporate on a tared watchglass, when the iodoform remains in the form of yellow crystals. The glass is put over H_2SO_4 for a short-time and is then weighed. 394 parts iodoform correspond to 58 parts acetone. Taking the S. G. of the wood spirit into consideration, the contents of acetone are easily calculated.

Methyl alcohol:

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Rectifying apparatus for methyl alcohol:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Methyl aldehyde see "FORMALDEHYDE".

Methyl chloride, methyl iodide, &c., see "METHYL COMPOUNDS".

Methylal. A condensation product corresponding to acetal (q. v.). It is methylene-di-methyl-ether. $CH_2(O \cdot CH_3)_2$.

Methyl alcohol is oxidized by warming with $MnO_2 + H_2SO_4$ and the reaction product, distilled. The product, containing methylal, methyl alcohol, formic acid and H_2O , is rectified and the fraction between 40 and 50° C collected. This is dehydrated by $CaCl_2$ and then with anhydrous K_2CO_3 , and repeatedly fractionated until a product distilling at 42° is obtained.

Colourless, mobile neutral liquid, smelling like chloroform and acetic ether, S. G. at (15°) 0.855, B. P. 42°, soluble in 3 parts H_2O , mixing with alcohol, ether and oils. It is used medicinally, externally as an ointment for lessening pain (1 part methylal, 30 parts olive oil) internally as a hypnotic in doses of 1—5 g and inhaled in doses of 30—50 g as an anaesthetic.

Methylamine see "METHYL COMPOUNDS".

Methylaniline see "ANILINE DERIVATIVES".

Methylatropine. Homologue of atropine (q. v.) used like the latter.

Methyl compounds. See METHYLALCOHOL, METHYL ANILINES under "ANILINE DERIVATIVES"; the methyl esters under the corresponding esters.

1. **DI-METHYLSULPHATE.** $(CH_3)_2SO_4$. It is obtained by decomposing methylhydrogensulphate $(CH_3)HSO_4$ at high temperatures. CH_3HSO_4 is obtained either from chloresulphonic acid and methyl alcohol, or from fuming H_2SO_4 and alcohol. The new Germ. Pat. 133542 is probably destined to

become important. SO_3 (quite free from H_2SO_4) is allowed to react with methyl alcohol below 0° and the reaction mixture distilled *in vacuo*. The methyl sulphuric acid thus obtained is then converted in the usual way into di methylsulphate at a higher temperature. It is valuable for alkylation, though great care must be taken in using it, as it is extremely poisonous.

2. METHYLAMINE. CH_3NH_2 . The Germ. Pat. 148054 is one of the new methods of producing it. The condensation products of aliphatic aldehydes with NH_3 or the mixture of aldehydes with NH_3 , or with NH_4 salts are electrolyzed in ammoniacal or neutral solution. For instance hexa-methylene-tetramine is electrolyzed in Na_2SO_4 solution with lead electrodes; the electrolyte is kept neutral by the addition of dilute H_2SO_4 in small quantities at a time; $(\text{NH}_4)_2\text{SO}_4$ may be used instead of Na_2SO_4 . The resulting mixture of methylamine and trimethylamine is distilled and the two compounds separated in the usual way. — French Pat. 334726 deals with the preparation of methylamine.

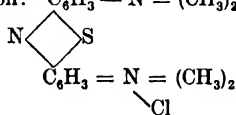
It is a colourless gas, smelling of ammonia, condensing on cooling to a liquid. B. P. — 6°C .

3. METHYL CHLORIDE. CH_3Cl . It is obtained by heating 1 part methyl alcohol with 3 parts H_2SO_4 and 2 parts HCl ; on a large scale it is prepared by heating methyl alcohol with crude concentrated HCl in autoclaves. Molasses and herring-brine are also used; they are distilled and the tri-methylamine collected in HCl . By heating the tri-methylamine hydrochloride $\text{N}(\text{CH}_3)_3\text{HCl}$ methyl chloride is obtained. It is a gas sold in the compressed state; used for refrigerating purposes.

4. METHYL IODIDE. CH_3I . Can be obtained by mixing 10 parts iodine with a cooled mixture of 4 parts methyl alcohol and 1 part amorphous phosphorus. After standing for 24 hours the CH_3I is distilled. The distillate is shaken with a solution of soda, the water removed by CaCl_2 , and redistilled. It is a heavy colourless liquid of sweetish smell; it turns brown on keeping. S. G. (at 0°) 2.1992; B. P. 43.8° . When treated with water in the cold it crystallizes as $2\text{CH}_3\text{I} + \text{H}_2\text{O}$. Methyl iodide is used in organic synthesis, particularly in the preparation of methylated coal-tar colours.

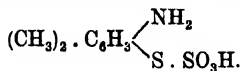
Methyldiphenylamine see "DIPHENYLAMINE".

Methylene blue. An important coal-tar colour, belonging to the oxazines and thiazines (q. v.). It is regarded as a tetramethylated thionine of the following constitution: $\text{C}_6\text{H}_3 - \text{N} = (\text{CH}_3)_2$

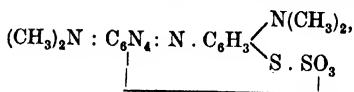


Formerly it was prepared by reducing a strongly acid solution of nitroso-dimethylamine with H_2S . Or the reduction was carried out with zinc dust and the resulting dimethyl-p-phenylenediamine oxidized with FeCl_3 in presence of a considerable excess of H_2S . In the formation of methylene blue two molecules of dimethyl-p-phenyldiamine combine with loss of one atom of N (as NH_3). The resulting colour is precipitated by adding common salt and zinc chloride and is sold as a double salt of zinc chloride.

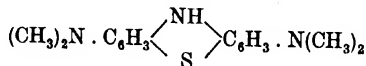
This method has been almost completely replaced by the more recent thio-sulphate process: p-amidodimethylaniline is oxidized in presence of sodium thio-sulphate to p-amidodimethylanilinetiosulphuric acid



This acid is oxidized with dimethylaniline and chromate to indamine (insoluble)



which is decomposed by boiling in zinc chloride solution. The leuco-base



is formed which on oxidation gives methylene blue.

Or, dimethyl-p-phenylenediamine is allowed to act on dimethylaniline in presence of thiosulphate; the hydrochloride of the product of the reaction may be recrystallized if a high degree of purity is required.

Methylene blue is also used medicinally, for malaria, neuralgia, &c. In the two latter cases it is given subcutaneously in doses of 1 g; for malaria, the same dose in capsule is given several times a day. It has been recommended as an external antiseptic, e.g. for painting diphtheretic membranes.

TEST: Volumetric determination of methylene blue is conducted according to L. PELET and V. GARUTI as follows (Chem.-Ztg., Repert. 1904, 323):

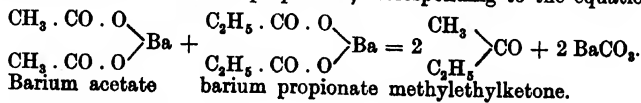
The methylene blue to be tested as well as the acid colours to be used in precipitation are dissolved in H_2O , to give a solution containing 1—2 parts per 1000. The acid dyes which give the least soluble precipitates with methylene blue (these being as little like the colour of the blue as possible) are crystal ponceau, carmine (as sodium salt), pyramine orange and cotton brown. Crystal ponceau is the most suitable for volumetric determination. The method is carried out as follows:— A definite volume of the methylene blue solution is put into a beaker and the acid colour solution gradually added. To ascertain whether the added acid dye is sufficient a drop of the solution is placed on filter paper and the coloured edge round the precipitate examined for colour, i.e. until it exhibits the colour of the acid dye added. Crystal ponceau and methylene blue combine in the ratio of 2 mol. of the latter to 1 mol. of the former, giving a definite compound of the formula $\text{C}_{52}\text{H}_{50}\text{N}_8\text{S}_4\text{O}_7$.

According to E. KNECHT (Chem. Ztg., Repert. 1905, 65) it is possible to determine methylene blue by titration with titanium trichloride (TiCl_3) in hydrochloric solution. Titration is conducted in an atmosphere of CO_2 ; the end-point is sharp and the results accurate.

Methylene chloride. CH_2Cl_2 . Commercially obtained by reduction of CHCl_3 with $\text{Zn} + \text{HCl}$. The product is purified by chemical treatment and is then fractionated.

When pure, it is a colourless liquid much like chloroform; S. G. (at 15°) 1.354; B. P. $41-42^\circ$. It must be kept in the dark. As it gradually decomposes an addition of 0.5—1 % absolute alcohol is recommended which causes the S. G. to sink to 1.351. It has been recommended as a substitute for CHCl_3 but has been but little used.

Methylethylketone. $\text{CH}_3 \cdot \text{CO} \cdot \text{C}_2\text{H}_5$. Is usually prepared by distilling barium acetate with barium propionate, corresponding to the equation.



It is a liquid B. P. 81° .

Methylsulphonal see "TRIONAL".

Metol see "PHOTOGRAPHIC CHEMICALS".

Mica. A double silicate of basic aluminium metasilicate and potassium (or sodium) metasilicate. It is metallic in appearance, silver-white to brownish-black in colour and can be split freely into colourless, thin, flexible sheets. Germ. Pat. 144162 protects a method for the use of mica as a cementing agent. Finely ground mica is mixed with $\text{Al}_2(\text{SO}_4)_3$ and a solution of agar-agar. The mass adheres to all materials, sets quickly and does not peel off. By adding glycerine or resin oils a certain degree of elasticity may be imparted.

Mica is used for making fireproof window-panes and lamp chimneys and has recently been employed in large quantities as an electrical insulating medium. See "MICANITE".

Micanite. Mica is an excellent electric insulator, as it does not burn and only melts at a very high temperature. It is non-hygroscopic and offers more resistance to high voltage electricity than any insulating material known. According to a report in a special pamphlet "Das Kabelwerk der allgemeinen Electricitätsgesellschaft" a small plate of perfectly clear transparent mica 0.038 mm in thickness cannot be pierced even by an alternating current of 10000 volt.

Perfectly clear pure mica is, however, rarely found in a natural state. The plates or flakes of mica are usually interspersed with metallic oxides, and this in a great measure interferes with the insulating properties. For this reason mica is usually separated into the different layers or flakes and the single segments then carefully fitted together again in the form and of the purity necessary for practical purposes. The need of larger pieces of a material equal to mica as an insulating substance has caused the introduction of a recently invented substitute called micanite. Micanite is a material made of small thin fragments of natural mica. The raw material is carefully separated, and the single flakes are then stuck together again by a suitable adhesive, one layer over the other to the requisite thickness. The metallic portions are removed during this process. The method of making the micanite is, briefly, as follows: First the single flakes are glued one on the other, as mentioned above, the adhesive chosen being usually shellac. The plates or moulded masses are then treated in a heated press, when owing to the simultaneous effect of heat and pressure, the alcohol contained in the adhesive evaporates, and the excess of shellac is removed.

Micanite is manufactured in plates of all sizes and thicknesses, or in the form of pipes, rinsers, collector rings and special shapes. Other products of mica are micanite paper, micanite linen, micanite gutta-percha and micanite asbestos.

Microscopy.

Great interest has been aroused recently by the researches of Siedentopf and Zsigmondy, who have succeeded in making visible sub-microscopic particles.

Particles which are beyond the resolving power of a microscope (about $\frac{1}{4}\mu$) are described as ultra-microscopic: if these can be rendered visible they are called sub-microscopic, in other cases they are called amicroscopic.

Siedentopf and Zsigmondy submit the particles to be examined to very strong illumination. The resolving power of the microscope is fixed by physical laws: the maximum lies at a magnification of about 900 diameters when two points at a distance from one another of 0.00016 mm can be distinguished. With a greater magnification the image appears larger but the details are not clearer. In order to observe particles still smaller than

those mentioned, the illumination must be so great that the lower limit of sensitiveness of the eye to light must be exceeded. It was on these lines that the two workers above-mentioned proceeded. The arrangement of the microscope is of the following nature. The particles are made self-luminous by means of a strong focal side-light. By means of lenses and diaphragms a powerful beam of convergent light, the axis of which is at right angles to the axis of the microscope, is brought to bear on the object under investigation. The self-luminous particles now throw diffraction images into the microscope and the illumination is so arranged that the axes of the light cone and of the diffraction cone are at right angles to one another. In consequence, the light cone, which is much stronger than the diffraction cone, does not coincide with the latter and so obscure it as would be the case if the illumination were from below.

Micro Catalogue M 184, Ultramicroscopy and Darkfield lighting micro 228—231; Carl Zeiss, Jena (Germany).

Migraineine. A mixture of caffeine citrate and antipyrine. A crystalline powder soluble in 2 parts cold water: more readily in alcohol and hot water. On account of its antipyretic and antineuralgic properties it is used medicinally in cases of headaches, influenza, neurasthenia, &c.

Migraineol. A clear brown liquid used externally for headache and toothache. It is a 10 % solution of menthol in acetic ester to which camphor and essential oils are added.

Migrophene. Mixture of lecithine and quinine. Prescribed for headaches in doses of 0.25 to 0.5 g.

Milk. The fresh warm milk is cooled in order to preserve it. The effect is more permanent if the microorganisms which cause the milk to turn sour be killed by heat, or if their development be arrested for some time. In preserving by heat we have to distinguish between sterilizing and pasteurizing. The former method consists in heating the milk to 100° C for $\frac{3}{4}$ —1 hour and then by a suitable method of closing the vessels, thus preventing fresh germs from entering. On a large scale the milk is placed in bottles or cans and sterilized by warming first to 85—90°, and then finishing the process by heating to 102°. In the household (preservation of nursery milk by SOXHLET'S method) the bottles are placed in a water bath, while on a large scale sterilization is effected by steam.

A patent milk sterilizer, constructed to hold 70—320 litre bottles, consists of a wrought iron box with a tightly fitting door, containing tin sheets perforated to receive the bottles; the steam enters at the bottom. Besides outlet taps, air valve and thermometer, an arrangement is provided which prevents a certain maximum pressure from being exceeded. The bottles are shut automatically inside the box.

A drawback of sterilization is that milk heated above 80° gets a cooked taste frequently regarded as disagreeable. This is avoided by pasteurization, which consists of a short heating to 65—80° (usually 75° C). The milk is gradually warmed previously and then completely pasteurized at the chosen temperature; the warming and final pasteurizing are usually carried out with steam. Suitable stirrers prevent irregular heating.

Pasteurization keeps milk sweet only for a certain limited time, but the boiled taste is avoided.

Germ. Pat. 148096 has for its object the preparation from skimmed milk of milk which will keep, is drinkable and may be used for cooking. For each litre of milk according to the amount of salts, which prevent precipitation

of yolk of egg on heating, as much as 30 g yolk of egg are added. The mixture obtained is pasteurized and sterilized in the usual way.

A drawback especially frequent in sterilized milk (less in pasteurized milk) is the gradual separation of the constituents, the cream gathering at the surface and below it the aqueous casein and salt solution. Various methods have been suggested to prevent this separation, e. g. shaking the bottles continually during the process of pasteurization. A better method is apparently that of GAULIN; the milk is made homogenous by breaking down the fat globules during heating, by means of high pressure.

Chemical means of preserving milk are on the whole not to be recommended, nor are they legal. Hydrogen peroxide has lately been recommended; its effects though not antiseptic are preserving.

On preserving milk by thickening, solidifying, &c., &c., see "MILK PREPARATIONS".

Milk preparations. The most important milk preparations are condensed milk, milk extract, and milk powder.

1. **CONDENSED MILK.** This is prepared by evaporating fresh milk *in vacuo*. In most cases about 12 % of cane sugar is added, and when the milk is reduced to $\frac{1}{3}$ to $\frac{1}{4}$ its volume it is placed in tins which are closed by soldering. The milk which is condensed without sugar does not keep nearly so well. According to Danish Pat. 6549 (1902) condensed milk is produced by forcing fresh milk under pressure through one or more colloidal filters; fat and caseine remain behind, while sugar and salts pass through in solution. The filtered substance is then evaporated almost to dryness, and finally again mixed with the fat and caseine. According to Germ. Pat. 143090 the milk is gradually poured on to a rotating refrigerator, which revolves so rapidly that only the ice formed from the water of the milk remains on the cylinder, while the other constituents are thrown off by the centrifugal force into a stationary receiver, built round the refrigerator; from this it is afterwards collected as condensed milk. See also Germ. Pat. 166847, 166848 and 167863.

2. **MILK EXTRACTS.** In a broad sense condensed milk is nothing but an extract of milk, but in the strict sense of the name, by milk extract is understood an article of luxury similar to extract of meat. The process of preparation is described as follows in Germ. Pat. 148419. Skimmed milk is peptonized and the milk sugar present inverted. The monose sugars resulting from this separation are fermented with yeast, after which the product is heated, filtered and evaporated. The Amer. Pat. 747678 dealing with the same problem proceeds thus:—Milk is treated with H_2SO_4 and heated, when the albumen is peptonized. The H_2SO_4 is then precipitated by CaCO_3 , the milk sugar is removed by crystallization, H_2O_2 is added to prevent fermentation and the substance is boiled with a small quantity of monopotassium phosphate. Mention can only be made here, for want of space, of Germ. Pat. 134697 for the production of a milk malt extract.

3. **MILK POWDER.** A distinction must be made clearly drawn between artificial and genuine milk powder. The artificial milk powders are mixtures of casein, butter-fat, milk sugar, and salts, which are intended to form, on being mixed with luke warm or hot water, a fluid in appearance and contents similar to milk. It is remarkable that just lately the Amer. Pat. 746502 has been taken out for a mixture of this kind which has been known for a long time. Several processes have been described for the preparation of powder from milk itself. Such as powder is obtained [Engl. Pat. 1786 (1902)] by drying milk either *in vacuo* or at the ordinary pressures at 75° C. or below. The milk must contain as much salt as is necessary for the solution of the albumen, so that eventually salts, and also non-crystallizing sugar or syrup must be added. This method by EKENBERG has been modified by the inventor,

in that the milk is mixed with carbohydrates (partially converted into dextrine), (Swedish Pat. 18845). The carbohydrates are prepared by treating starch in presence of H_2O with oxidizing agents such as $KMnO_4$, Cl , ozone, &c., and then acting upon the mixture with dilute acids. According to Engl. Pat. 21617 (1902), the milk is heated either in extremely shallow vessels or in the form of a fine shower, so that the water may pass off rapidly. In this case also salts are added to prevent the albumen from being made insoluble. Germ. Pat. 150473 differs but slightly from this method. According to Amer. Pat. 723254 steam is blown through the milk till a temperature of about $93^\circ C$ is reached, the milk is then concentrated *in vacuo* at about $43^\circ C$ to about $23^\circ B\acute{e}$, the condensed product mixed with the same weight of prepared milk powder, the mixture dried and finally brought to the consistency of a fine powder.

A butter milk in the form of powder has lately been brought on the market under the name of LACTOSERVE. It is made by sterilizing good milk by PASTEUR's method, then subjecting it to the action of lactic acid bacteria, at a temperature of 36° , until a certain degree of acidity is obtained. The product is then dried *in vacuo* at 50° . The residue is ground and mixed in the proportion of 300 g of sugar, 100 g of wheat flour and 20 g of borate to 1600 g of the powdered milk. The preparation forms a white flour of the following composition, dry matter 89.36 %, albumen 22.94 %, fat 11.28 %, carbohydrates 51.70 %, salts 5.02 %. By adding 200 g of this powder to 1 litre of boiling water an emulsion resembling fresh butter milk is obtained which is said to prove a good and nourishing food for children, especially in cases of intestinal trouble.

See also Germ. Pat. 179657, 183319, 183974, and Amer. Pat. 860327.

Compare also the article on "MOLCOSE".

Milk condensing apparatus:

G. Scott & Son Ltd., 2 Talbot Court, London E.C.

Milk condensing plant:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Milk preserving apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Milk sugar (Lactose). $C_{12}H_{22}O_{11}$. The raw material used in the manufacture of milk sugar is whey, i. e. the liquid remaining, after separating the casein in cheese making. The whey, free from curd, is evaporated until the sugar crystallizes out. To purify it, it is re-dissolved, filtered through animal charcoal and re-crystallized. The process used in the manufacture of beet sugar is frequently followed. The whey is boiled with milk of lime, saturated and filtered &c. (see "MOLASSES" and "SUGAR MANUFACTURE").

According to the Amer. Pat. 730703 the whey is made slightly alkaline, evaporated to half its original volume, freed from proteids, again evaporated to $\frac{1}{6}$ of its volume, and the lactose precipitated with alcohol.

Other methods of preparing milk sugar are proposed in the Amer. Pat. 772517 and in the Swedish Pat. 18221 (1904), though these methods contain nothing materially new. According to Germ. Pat. 184300 milk sugar is obtained from milk by precipitation of the casein with SO_2 . From the filtrate the milk sugar is obtained in the usual way.

Purified milk sugar forms pure white crystals with a slightly sweet taste. It dissolves in 6 parts of cold water and 2.5 parts boiling water.

Millenium light. Coal gas compressed under a pressure equal to a column of water 1.3 m high and burnt in special burners. Light of 1800 candle power can be thus obtained for a small consumption of gas.

Mills.**Mills for mixing pigments:**

Werner Pfeiderer & Perkins Ltd., Peterborough.

Grinding Mills:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Max Friedrich & Co., Leipzig-Plagwitz 17.

Edgemills:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Edgemills with runner and bed stones of granite:

J. M. Lehmann, Dresden-A. 28, Germany (see front part advt.).

Mineral colours see under respective metals.

Mineral tanning. For general details as to the preparation of the hides, see "TANNING". The process differs from the ordinary methods of tanning in that the materials used for treating the hides are of inorganic and not of organic origin. White leathers are obtained by the use of aluminium salts. Chromium salts are now very largely used (chrome leather), and so also are iron compounds.

In alum dressing the clean unhaird hides are drawn backwards and forwards through a bath of alum and common salt, hung up without washing and allowed to dry. When dry, the stiff leather is softened by moistening and scraping with knives.

In the preparation of glacé leather the liming and unhairing must be carefully performed; yolk of egg and wheat flour are also added to the alum and salt bath. A quick method is described by French Pat. 334006, according to which the hides are first treated with alum and salt and then placed at once into strong vegetable tannage. This process is said not to damage the leather.

Chrome tanning is carried out by two methods both of which had their origin in America, viz. the one-bath process or the two-bath process. Only salts of chromic oxide have any tanning effect on the hide and of these the basic salts are most effective. Salts of chromic acid must on the contrary be reduced to chromic compounds. In the one-bath method the hides are treated with solutions of salts, more especially basic chromium sulphate and chromium oxychloride. In the other method the goods are first steeped in a solution of $K_2Cr_2O_7$ or $Na_2Cr_2O_7$, acidified with HCl. In the second bath the chromate is reduced to the chromic state usually by a solution of sodium thiosulphate to which HCl is added. Afterwards the tannage is fixed by treatment with solutions of lead acetate, barium chloride or soap. The leather is finally washed, dried, stretched and greased by dipping it into a warm benzine solution of paraffin. The details of the chrome-tanning process have been greatly modified. For example, chrome tanning has been combined with vegetable tanning so that a leather is obtained which has the properties of the two kinds of leather.

The great success of chrome leather is due not only to the short time occupied in tanning but also to its strength, impenetrability and resistance to external influences such as steam and high temperatures.

It is interesting to note that processes have been recently introduced in which the hides are tanned and dyed simultaneously in the same bath. See Amer. Pat. 622563 and Germ. Pat. 133757. According to the latter, by the proper choice of dyestuff on the one hand and of chromium salts on the other dyeings may be obtained which are faster than those produced by

dyeing after tanning. The dyestuffs belong to different groups, but they must neither be precipitated by chromium salts alone nor on addition of tannin, or if they do it must be to such a slight extent that after filtering the filtrate still contains sufficient colouring matter. Chrome alum, chromium chloride, bisulphite, or thiosulphate may be used, best in the form of basic salts.

In tanning dilute solutions are first used, e. g. $\frac{1}{2}$ to 1° Bé. These are gradually strengthened to 6° Bé. The dyestuffs which may be used are:— oxidized logwood extract, carmine colours for wool, metanil yellow, orange II, &c., &c.

Further, materials may be used which give coloured compounds on oxidation, e. g. pyrogallie acid, p-amidophenol, dimethyl-p-phenylenediamine, &c. In this case the latter is subsequently treated with a $\frac{1}{2}$ % solution of bichromate. Finally the hides may be dyed and then tanned. For this method metanil yellow, solid green, erioglaurine, rhodamine, acid violet, &c., &c. may be employed. The dyeing is best performed in presence of alum and common salt.

The Germ. Pat. 157467 treats of a process for colouring chrome leather by treating it first with a solution of sulphur dyes and afterwards with acidified solutions of basic dyes. According to Germ. Pat. 162278 a simultaneous "fatting" and dyeing of chrome leather is attained by adding to the alkaline fat emulsion the solution of a sulphur dye and also a substance which like formaldehyde, glucose, tannin, &c. protects the leather from the action of sodium sulphide.

The observation that in the two bath process the chromic acid first oxidizes the hide and then this oxidized hide combines with chromium oxide to form leather, has led to the Germ. Pat. 148796 (FAHRIONI'S process), in which the oxidation of the hide is carried out in a special operation with hydrogen peroxide; this oxidized hide can then be tanned by solutions of chrome alum, chromium sulphate, chromic chloride, &c., without any addition of Na_2CO_3 .

In iron tanning, which by the way has not found much favour, the hides are tanned with basic ferric sulphate. One drawback is that the iron leather cannot be greased with tallow but only with iron soaps and fatty emulsions.

Recently other mineral salts have also been proposed for tanning; thus according to the French Pat. 327945 and the Engl. Pat. 25597 (1902) titanium salts can be used for tanning, while the Germ. Pat. 144093 employs tin salts with the same object. With regard to the simultaneous tanning and dyeing by means of titanium salts see "LEATHER".

A great advantage of the mineral tanning is the quickness with which the leather is finished, to which in the case of white tanned leather there is the advantage that it can with ease be dyed all possible shades. Formerly it was said that the chrome leather was not so durable as that obtained by vegetable tanning, but this does not now apply, at least not in so far as chrome leather is concerned. It is to be expected that the demand for chrome leather will increase, and that for many purposes it will displace the vegetable tanned material.

Mineral oils. This is the general name applied to the oils obtained by the distillation of petroleum as well as to those obtained by the dry distillation of coal, brown coal, wood, peat, and bituminous shale, in so far as they are used for illuminating purposes and as lubricants for machines. See also the articles on "BROWN COAL TAR", "WOOD TAR", "PARAFFIN", "PETROLEUM", "SHALE OIL", "LUBRICANTS", "SOLAR OIL", "COAL TAR", "VASELINE".

What are usually known nowadays as mineral oils are those obtained from the waste products of the petroleum distillation. In this process — after driving off those constituents which volatilize below 280° — there remain substances which are gradually heated to 270° by high pressure steam in order to obtain the mineral lubricating oil. The heavy oils distil and are

condensed by means of a specially constructed condensing receiver which allows of a separation of the different fractions. The distillation is usually carried out under diminished pressure.

The mineral oils thus obtained are then submitted to a chemical purification which is very similar to that employed in the case of petroleum. The oils are first treated with 5 % H_2SO_4 , the mixing being brought about by air blown through the mixture. They are then washed with water, shaken with NaOH to remove the last traces of H_2SO_4 , and finally repeatedly washed with H_2O . In order to decolourize the oils they are filtered in the warm state through animal charcoal. According to Germ. Pat. 161924 the crude mineral oils can be refined by treating for a long time with a saturated solution of NaCl and Na_2CO_3 , a current of air being simultaneously blown through the mixture. By adding some granular material the salt solution is obtained in a finely divided state. The oil is finally distilled in the presence of an oxidizing manganese compound. A modification of this process is Germ. Pat. 161925. To render the oils odourless they are treated according to Germ. Pat. 147163 with aldehydes and ketones — especially with formaldehyde — at the same time they are heated, and either acid or alkali added; steam is afterwards passed through. — WEBER claims to attain the same object by shaking with oils containing turpentine and alkali. The process of the Germ. Pat. 153585 for the treatment of crude mineral oils with a view of obtaining odourless viscous oils on the one hand and light oils free from S on the other consists in treating the oil with 1 % neutral or basic lead acetate in aqueous solution. It is convenient to have this solution of the same S. G. as the oil. It is then distilled at 180° with high pressure steam until at least 20 % of the oil has distilled over. The residue forms an almost odourless and colourless thick oil; the distillate is a light burning and motor-oil free from sulphur.

The manufacture of the so-called soluble mineral oils has become important. On account of the percentage of alkali soap they are readily soluble in water and are employed in mixtures for lubricating machines, as an oiling substance in wool spinning, &c. According to the process of BOLEG (Germ. Pats. 122451, 129480 and 148168) mineral oils (heavy tar oils) are rendered soluble in water by the addition of unrefined resinous oils and saponification of the resinous acids contained therein by means of alkali (or by soaps of certain fatty sulphonic acids, oleic acids and naphthene acids) with subsequent oxidizing action under pressure. They are rendered capable of dissolving considerable quantities of water yielding a clear solution. The latest BOLEG's patent is Germ. Pat. 155288;— according to this the process is as follows: The hydrocarbons are gradually heated in a closed apparatus connected with a condenser by means of steam to 50 — 70° and at the same time fine jets of compressed air are forced through. A small amount of NaOH and water is also usually admitted. The mineral oils thus treated are then well mixed with saponified resinous oils, and air is again allowed to enter. The whole is finally heated in digesters under pressure. Such soluble mineral oils are now used with advantage for sprinkling streets; the product used for this purpose bears the name "WESTRUMITE".

Germ. Pat. 169493 and 170332 protect the preparation of aqueous emulsions of mineral oils with the help of caseine solutions or preferably decomposition products of caseine and other proteids (e. g. glue). Such products are obtained by the action of KOH on caseine.

There are numerous brands of mineral oils.

The following notes are taken from BENDERS (DAMMER "Handbuch der chemischen Technologie", Bd. III, Stuttgart 1896).

Generally speaking a difference between machine and cylinder oils is recognized; the former is the distillate from solar or mixed oil and the latter the highest boiling distillate. The Russian machine oils are superior to the American in viscosity; but the American cylinder oil is on the whole superior to the Russian.

The specific gravities and ignition points are as follows:

RUSSIAN OILS.

Machine oil. S. G. 0.893—0.920. Ignition point¹⁾ 138—197°.

Cylinder oil. S. G. 0.911—0.923. Ignition point¹⁾ 188—238°.

AMERICAN OILS.

Machine oil. S. G. 0.884—0.920. Ignition point 187—206°.

Cylinder oil. S. G. 0.886—0.899. Ignition point 280—283°.

With regard to the viscosity the following has been ascertained:—

Russian oil. Spindle oils of S. G. 0.893—0.895 have at 50° (water as standard = 1) a viscosity 3.15—3.44; light oils (substitute for rape oil, &c.) S. G. 0.911—0.923 have a viscosity 5.86—6.34; cylinder oils of S. G. 0.911 to 0.923 have a viscosity 2.07—2.88 at 100°.

With the American oils the viscosity of spindle oils of S. G. 0.908—0.911 was found to be 3.13—3.32 at 50°. Cylinder oils of S. G. 0.886—0.899 was 4.17—4.82 at 100°.

The relations of boiling points to specific gravities are as follows:

	American oils S. G.	Russian oils S. G.
Spindle oil	0.908—0.911	0.893—0.895
Light machine oil	0.920	0.903—0.905
Dark machine oil	0.884	0.900—0.920
Cylinder oil	0.886—0.889	0.911—0.923

As an average the percentage of the oils which boil below 310° is in machine oils 7 % and in cylinder oils 23 % by volume. The American oils S. G. 0.908 to 0.920 or 0.884—0.899 correspond in viscosity to the Russian oils S. G. 0.893—0.900 or 0.900—0.923.

That a determination of the value of the oils according to the specific gravities is inadmissible may be seen from the above results. It will be noticed that neither ignition point nor viscosity stand in uniform relation to the S. G.

With regard to the behaviour to cold the Russian oils have in general the preference over the American as only at a temperature of — 10° do they freeze to a clear mass, while the American oils in the neighbourhood of 0° begin to precipitate paraffin-like substances.

The German oils (Elsass, Ölheim) correspond to the Russian in so far as the viscosity and ignition point increase with increasing specific gravity; but they differ on the other hand in their slight viscosity and unfavourable behaviour in the cold. For the same specific gravities the viscosity of the Elsass oils exceeds that of the American, but the ignition point is lower.

¹⁾ Determined in open crucible.

According to HOLDE ("Untersuchung der Schmiermittel usw.", Berlin 1897)¹⁾ with regard to their uses the mineral lubricating oils may be divided into the following classes:

1. Spindle oils for spinning machines, light mobile oil of fe 5—12 at 20°, fp PENSKY 160—200°C, distilling under very diminished pressure.

2. Ice-machine or compressor oils, mobile, fe at 20° = 5—7; ep below —20°C; fp PENSKY between 140—180°C. These oils must possess a very low freezing limit on account of their use.

3. Light machine, transmission, motor, and dynamo oils, moderately viscous, fe at 20°C = 13—25; fp PENSKY 160—210°.

4) Heavy transmission, and machine oils, very viscous, fe at 20°C = 25—45, in some cases up to 60; fp PENSKY 160—210°.

The above mentioned groups of oils are, as a rule, refined and appear in a test tube brownish-yellow to brownish-red in colour, some of the dearer oils of the group 1—3 are even colourless. Less valuable heavy machine oils are non-transparent in a test tube.

5. Dark railway- and locomotive oils, fe for summer oils at 20° 45—60°; for winter oils 25—45; fp PENSKY above 140°C, ep for summer oil under —5°; for winter oils under —16°C. The above qualities are required by the Prussian railways.

6. Steam cylinder oils, highest boiling products of distillation of very viscous or vaseline-like constituency, which either at ordinary temperature or several degrees above 0° freeze to thin vaseline-like masses; fe at 50°C = 23—45. According as they are wholly or partially distilled they are brownish-red and transparent or greenish-black and opaque. In direct light also the distilled lighter oils usually appear greyish-green. fp PENSKY lies according to the quality of the oil between 220 and 315°C.

With regard to lubrication little is clearly known according to C. Ch. SCHMIDT (Riga Industriezeitung 1904, 258) as published in the Referat der (Chem. Zeitschr. IV (1905, 185). The principal object of the lubricating oil is to keep the two rubbing surfaces so far apart that the metals do not directly touch; more work is necessary to overcome the internal friction of the oil itself. A good oil should cause little friction, that is, it must be mobile and not thick, but keep the metallic surfaces apart. The processes which take place in the lubricating layer are first of a chemical nature — formation of soap-like substances, also real metallic soaps — and secondly of a physical nature. But in this last direction there is still much to be explained. In places where there is high pressure (for bearing lubrication) the use of fatty mineral oils can be theoretically recommended. In other places the thinner mineral oils may be used, so that it is advantageous to employ mixtures of fatty and mineral oils. The principal requirement of a good cylinder oil is the resistance to high temperature and to the mechanical and chemical action of superheated steam. For ordinary high pressure steam an oil with an ignition point above 220° is sufficient; with oils intended for high pressure steam an oil with ignition temperature of 300° is necessary. A steam temperature of 350° decomposes all oils. Further requirements for a good cylinder oil are strong adhesive powers and high viscosity, and the absence of resinous and pitch-like constituents. To choose a very viscous oil for the sake of economy is quite wrong in principle, for at the temperature of the steam the most viscous oil becomes as thin as water. For instance the viscosity of

¹⁾ In Holde's accounts the abbreviations denote:— ep = Freezing point. fp = Pensky ignition point determined in the Pensky Martens' apparatus; fe = degree of liquidity determined in Engler's viscometer. The degree of liquidity is the quotient of the time of outflow of 200 ccm oil (determined at the temperature of experiment) and the time of outflow of 200 ccm H₂O at 20° C.

progress oil 0 was in the ENGLER's apparatus at 70° 270 sec., at 100° 116, at 150° 74 and at 170° 67 sec.: of a mineral hot-steam oil at 70° 835, at 100° 226, at 150° 93 and at 170° 73 sec. In the following table are the constants of some of the commercial cylinder oils:

Cylinder oils for ordinary steam.

Name	S. G. at 14° R	Viscosity at 10° C, sec.	Ignition point 0° C
Cylinder oil (Nobel)	0.913	313	232
Hübner's cylinder oil	—	893	228
American Tribi oil	0.893	202	209
Cylinder oil OO of Schibajew	0.934	308	238
Progress oil 0	0.921	270	245

Cylinder oils for superheated steam.

Name	S. G. at 14° R	Viscosity at 10° C, sec.	Ignition point 0° C
American valvoline	0.905	721	304
Moehring's cylinder oil	0.903	645	293
English " "	0.906	758	307
Diamant " "	0.906	700	307
Hamburg " "	0.901	504	330
American dark cylinder oil	0.899	706	313
Meyrer's cylinder oil	0.908	937	333
Vacuum valvoline (Ropes)	0.938	1115	311
Vacuum cylinder oil	0.907	648	330
English, " "	0.900	763	331
Snowdons " "	0.901	732	333
Progress oil HOO	0.932	730	345

For further information on mineral oils see the articles on "SHALE OIL", "PETROLEUM", "BENZINE", "VASELINE", &c.

Mineral waters, artificial. The ordinary refreshing drinks may be considered apart from those artificial mineral waters which are intended to imitate springs of therapeutic value. The former, also called aerated waters, seltzer and soda waters contain as a rule few salts, a little NaCl and Na₂CO₃; they are saturated with CO₂ under pressure.

The apparatus used to prepare artificial mineral waters is devised with the object of forcing carbonic acid into the water under pressure. Formerly, only those forms of apparatus were used in which CO₂ was developed, purified and absorbed, while at present many forms employ liquid carbonic acid (q. v.) sold in steel flasks. Saturation with CO₂ is usually carried out under a pressure of 5 atm. though the mineral water when finished in the bottles is rarely under a higher pressure than 1.5 to 2.5 atm.

The CO₂ generators are mostly of copper, lined on the inside with lead, but apparatus of earthenware is also used.

They are divided into pump-apparatus and automatic developers. In the former the CO₂ developed is received in gasometers and forced from there into the water by means of a pressure pump, while in the automatic developers the pressure of the gases evolved is utilized. Marble, chalk, magnesite, and H₂SO₄ or HCl are used to develop the CO₂. The gas must under all circumstances be purified before use, by passing through various vessels containing pure water, caustic soda, and finally a solution of FeSO₄ and NaHCO₃ (the

latter to absorb the H_2S). The CO_2 has to pass through a solution of potassium permanganate to remove disagreeable odours.

The mixing vessels for H_2O and CO_2 consist of tin-plated copper, enamelled iron or earthenware: they are usually constructed on the principle of counter-currents.

Before saturation the water together with the salts to be dissolved is brought into the mixing vessel. Aerated waters without ingredients of this kind are rarely made as they taste flat and allow the CO_2 to escape rapidly. The usual so-called "seltzer" contains about 25 g crystallized Na_2CO_3 , 5 g NaCl and 6 g crystallized Na_2SO_4 per 10 litres of H_2O .

In making mineral waters it is best to employ distilled water, in which case a distilling apparatus is also provided as the purchase of distilled water would be too expensive.

The contrivances for filling vessels with mineral waters are combined with the corking machines so as to reduce the loss of CO_2 to a minimum.

As regards medical mineral waters they are as a rule compounded according to the chemical analyses of the respective natural waters but with regard to the chemical transformations which take place between the various salts. Not infrequently substances therapeutically superfluous or useless are left out. The saturation with CO_2 is usually greater than in the natural waters. All medical mineral waters should be prepared exclusively from distilled water.

Besides the most varied natural and artificial mineral waters the corresponding "mineral salts" also are sold, obtained either by evaporation of the natural waters or by mixing according to analytical results. The artificial mixtures frequently fulfil their purpose better than the natural ones as by evaporation of the natural waters decompositions and transformations (caused especially by the escape of CO_2) take place. All of these salts do not dissolve in pure water, as many dissolve only in the presence of CO_2 .

COMPOSITION OF THE MOST IMPORTANT ARTIFICIAL MINERAL WATERS.

In each case the quantities given are for 100 kg water.

1. APOLLINARIS: 216.985 NaHCO_3 , 4.4695 NaCl , 2.7856 Na_2SiO_3 , 28.945 CaCl_2 , 42.773 $\text{MgCO}_3 + 3 \text{H}_2\text{O}$, 16.731 MgSO_4 , 2.902 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$, 1.6668 HCl .
2. BILIN: 12.693 Na_2SiO_3 , 0.0947 Na_3PO_4 , 5.4315 Na_2SO_4 , 34.6342 NaCl , 2.2553 LiCl , 19.188 K_2CO_3 , 371.241 Na_2CO_3 , 0.6756 FeSO_4 , 1.248 HCl , 0.0222 $\text{MnSO}_4 + 4 \text{H}_2\text{O}$, 0.07853 AlCl_3 , 62.457 $\text{CaSO}_4 + 2 \text{H}_2\text{O}$, 24.969 MgSO_4 .
3. EMSER KRAENCHEN: 10.1142 Na_2SiO_3 , 0.1841 Na_3PO_4 , 0.00224 NaI , 0.03398 NaBr , 164.9 Na_2CO_3 , 63.625 NaCl , 2.916 K_2CO_3 , 0.01282 AlCl_3 , 0.0215 $\text{MnCl}_2 + 4 \text{H}_2\text{O}$, 0.3455 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$, 1.691 SO_3 , 0.2916 LiCl , 0.1935 SrCl_2 , 0.0885 BaCl_2 , 16.663 CaCl_2 , 13.395 MgCl_2 , 0.2219 $(\text{NH}_4)_2\text{SO}_4$, 2.484 MgSO_4 .
4. FACHINGEN: 5.1849 Na_2SiO_3 , 0.0707 $\text{B}_2\text{O}_7\text{Na}_2 + 10 \text{H}_2\text{O}$, 0.00095 NaI , 0.02343 NaBr , 0.0963 NaNO_3 , 0.1512 NH_4Cl , 0.5219 LiCl , 0.8074 KCl , 1.092 $\text{MnCl}_2 + 4 \text{H}_2\text{O}$, 0.907 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$, 1.939 SO_3 , 0.026 BaCl_2 , 0.333 SrCl_2 , 5.0988 CaCl_2 , 42.826 MgCl_2 , 38.83 CaCO_3 , 305.56 Na_2CO_3 .
5. GIESSHUEBELER SAUERBRUNNEN: 1.133 NaCl , 1.448 Na_2SO_4 , 11590 Na_2SiO_3 , 78.233 Na_2CO_3 , 16.00 CaCO_3 , 14.967 $\text{MgCO}_3 + 3 \text{H}_2\text{O}$, 0.86 AlCl_3 , 2.157 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$.
6. HUNYADI JANOS: 2.2810 Na_2SiO_3 , 90.496 Na_2CO_3 , 28.683 NaCl , 1980.354 Na_2SO_4 , 1949.423 MgSO_4 , 13.294 K_2SO_4 , 107.893 CaCl_2 , 0.4934 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$.
7. KARLSBADER SPRUDEL: 14.538 Na_2SiO_3 , 0.069 Na_3PO_4 , 0.764 $\text{B}_2\text{O}_7\text{Na}_2 + 10 \text{H}_2\text{O}$, 0.508 NaF , 1.417 LiCl , 177.212 Na_2CO_3 , 64.353 NaCl , 0.1047 AlCl_3 , 0.7333 $\text{FeSO}_4 + 7 \text{H}_2\text{O}$, 0.028 $\text{MnCl}_2 + 4 \text{H}_2\text{O}$, 2.000 SO_3 , 208.42 Na_2SO_4 , 18.64 K_2SO_4 , 23.79 MgSO_4 , 0.046 SrCl_2 , 35.76 CaCl_2 .

8. KREUZNACHER ELISABETHQUELLE: 2.7145 SiO_2Na_2 , 0.3588 $\text{B}_2\text{O}_3\text{Na}_2$, + 10 H_2O , 0.0423 AsO_4Na_3 , 0.0582 PO_4Na_3 , 0.0431 NaI , 4.9882 NaBr , 6.5640 LiCl , 2.2155 NH_4Cl , 15.2642 KCl , 990.016 NaCl , 54.696 Na_2CO_3 , 0.1528 MnCl_2 + 4 H_2O , 4.2554 FeCl_2 + 2 H_2O , 0.0526 AlCl_3 , 0.7674 ZnCl_2 , 26.8544 MgCl_2 , 6.465 BaCl_2 , 7.961 SrCl_2 , 211.918 CaCl_2 , 5.141 HCl .

9. MARIENBADER KREUZBRUNNEN: 8.8247 SiO_2Na_2 , 0.3234 PO_4Na_3 , 0.4092 NO_3Na , 1.1333 LiCl , 60.6937 KCl , 0.2670 NH_4Cl , 38.6920 NaCl , 220.0750 Na_2CO_3 , 443.9930 Na_2SO_4 , 0.5235 AlCl_3 , 0.5856 MnCl_2 + 4 H_2O , 3.2433 FeSO_4 + 7 H_2O , 37.6200 MgSO_4 , 5.1410 HCl , 64.8160 CaCl_2 , 0.0765 SrCl_2 , 0.0408 BaCl_2 .

10. SELTERS: 0.0033 NaI , 0.0909 NaBr , 0.0806 Na_3PO_4 , 0.4217 K_2CO_3 , 0.6110 NaNO_3 , 1.7630 KCl , 4.0983 K_2SO_4 , 4.3208 Na_2SiO_3 , 145.7412 Na_2CO_3 , 164.8454 NaCl , 0.0176 BaCl_2 , 0.0470 AlCl_3 , 0.2342 SrCl_2 , 0.5227 NH_4Cl , 22.8677 MgCl_2 , 34.2131 CaCl_2 , 0.3130 Li_2CO_3 , 2.2288 HCl , 0.0989 MnSO_4 + 4 H_2O , 0.7262 FeSO_4 + 7 H_2O .

11. VICHY: 0.0026 NaI , 0.013 NaBr , 0.422 Na_3PO_4 , 13.026 Na_2SiO_3 , 20.404 K_2SO_4 , 22.686 NaCl , 409.465 Na_2CO_3 , 0.203 AlCl_3 , 0.249 SrCl_2 , 0.523 NH_4Cl , 3.991 MgCl_2 , 27.753 CaCl_2 , 0.076 MnSO_4 + 4 H_2O , 0.281 FeSO_4 + 7 H_2O , 6.524 SO_3 .

12. WEILBACHER SCHWEFELQUELLE: 0.053 Li_2CO_3 , 0.057 Na_3PO_4 , 2.958 Na_2SiO_3 , 2.570 K_2CO_3 , 3.885 K_2SO_4 , 50.737 Na_2CO_3 , 0.011 SrCl_2 , 0.018 AlCl_3 , 0.107 BaCl_2 , 0.533 NH_4Cl , 1.875 CaCO_3 , 27.163 CaCl_2 , 38.722 MgCO_3 + 3 H_2O , 189.0, sulphuretted hydrogen water (0.4 %).

13. WIESBADENER KOCHBRUNNEN: 18.2392 KCl , 619.1652 NaCl , 0.4351 NaBr , 0.0017 NaI , 8.4072 Na_2SO_4 , 40.2767 Na_2CO_3 , 0.0030 Na_3PO_4 , 0.1574 $\text{Na}_2\text{B}_4\text{O}_7$ + 10 H_2O , 12.7518 Na_2SiO_3 , 2.3104 LiCl , 1.7073 NH_4Cl , 98.3377 CaCl_2 , 0.1332 BaCl_2 , 1.8943 SrCl_2 , 20.0872 MgCl_2 , 1.6129 FeSO_4 + 7 H_2O , 0.1734 MnSO_4 + 4 H_2O , 0.0235 Na_3AsO_4 .

14. WILDUNGEN GEORG VICTORQUELLE: 0.9280 K_2SO_4 , 2.9405 Na_2CO_3 , 0.7132 NaCl , 4.4076 Na_2SiO_3 , 0.0087 Na_3PO_4 , 4.0141 Na_2SO_4 , 0.0338 $(\text{NH}_4)_2\text{CO}_3$, 0.0483 Li_2CO_3 , 0.0337 AlCl_3 , 0.0014 BaCl_2 , 50.8291 CaCO_3 , 59.7139 MgCO_3 + 3 H_2O , 5.2036 FeSO_4 + 7 H_2O , 0.3058 MnSO_4 + 4 H_2O .

Minium see "LEAD COLOURS".

Mirbane, oil of, see "NITROBENZENE".

Mitine. A new base for ointments prepared from an emulsion which is superfatted with a non-emulsifying fat: it contains about 50 % of a serum-like liquid.

It keeps well, can be mixed with most substances and is capable of taking up a further quantity of liquid.

Wool-fat is used as the fat and milk or a solution of the proteids obtained from it is used as the serum-like fluid.

Mitine cream, powder, soap, &c. are also prepared.

Mixing Machines.

Mixing Machines:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Werner Pfleiderer & Perkins Ltd., Peterborough.

Mixing Apparatus:

G. Scott & Son Ltd., 2 Talbot Court, London E.C.

Mixing Machinery:

W. Stamm, 25 College Hill, London E.C. Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Molasses.

In the manufacture of sugar *q. v.* there remains after the crystallisable sugars have been removed, a thick brown peculiarly unpleasant smelling liquid from which, although it contains about 50% of sugar, it is impossible by mere concentration to obtain sugar in the crystalline state. It was formerly the practice to use the molasses partly as a feeding-stuff and partly for the preparation of alcohol. Now, however, it is possible to prepare from the molasses a crystalline sugar. Three methods are described of which only the third is of real value.

1. OSMOSIS METHOD.

This method is based on the principle of diffusion (see Sugar Manufacture). Crystalloids in solution can diffuse through parchment paper while colloids remain behind. The apparatus used is of the following type. Sets of chambers of the filterpress kind are arranged so that they are separated from each other by parchment paper. Chambers 1, 3, 5, 7, etc. are filled with warm molasses and chambers 2, 4, 6, 8 with warm water. From time to time the liquids are led through the apparatus in opposite directions. The salts in the molasses diffuse more quickly than the sugar so that the sugar solution becomes continually purer. After the operation has been repeated three times the solution is evaporated and the sugar (to the extent of 25 to 28%) recovered by crystallization.

2. CALCIUM SACCHARATE METHOD.

a) Extraction process. The molasses is mixed with three times its weight of slaked lime: on cooling the whole of the sugar separates as a compound with the calcium. The mass is dried and washed with alcohol (35° Tl.) to remove salts. Since the drying of the lime compound is a difficult process quicklime may be used in place of the slaked lime. In this way there is obtained in one operation a dry mass which can be readily extracted. The extraction takes place in cylindrical vessels of which 6—8 are combined to form a battery. The calcium saccharate is not as a rule worked up into sugar but is used instead of pure lime in the manufacture of sugar (*q. v.*).

b) Separation method. The molasses are diluted until they contain not more than 7% of sugar and cooled below 15°. For every 100 parts of molasses there are then added 60—70 parts of powdered quick lime. The sugar is precipitated as tricalcium saccharate which is filtered off and washed with cold water. This may be used as above described or it may be decomposed with lukewarm water, when the mono saccharate goes into solution while $\frac{2}{3}$ of the lime is precipitated. The solution is filtered and saturated with (O_2) to remove the remaining third of the lime. In this way is obtained a sugar solution from which a sugar which crystallizes well and has a good taste can be obtained.

3. STRONTIUM METHOD.

This is described in the new and improved Scheibler modification. The molasses are treated with so much of a hot saturated solution of strontium hydroxide that the mixture contains for every molecule of sugar 0.5 mol. of $\text{Sr}(\text{OH})_2$. The solution is warmed to 70°, cooled and filtered, when 75—80% of the sugar separates as monostrontium saccharate. The solution of this substance is diluted until it contains 20% of sugar and is then treated with

CO₂ until only 0.04—0.06% of SrO remains. The pure sugar solution is then worked up in the usual way.

In the liquid obtained after the monosaccharate has been separated there yet remains from 20 to 25% of sugar. By adding more Sr(OH)₂ the disaccharate is precipitated and this can be converted by the addition of more molasses into monosaccharate.

Other methods for obtaining sugar from molasses are of no importance. See also "DISTILLERS' WASH".

Molcose. A food preparation recommended for debility in children and for convalescents. It contains 22.7 % of proteid obtained from milk.

Molecular weight.

FORMULAE FOR DETERMINING MOLECULAR WEIGHT.

A. VICTOR MEYER'S METHOD OF DETERMINING THE VAPOUR DENSITY. Let G be the weight of the substance, B the height of barometer reduced to 0° C, ω the tension of water at t°, v the volume of air measured, t the temperature of the room and D the vapour density, i. e. the volume weight of the vapour relative to air. The following formula holds:

$$D = \frac{G \cdot 760 (1 + 0.003665 t)}{(B - \omega) V \cdot 0.0012934} = 587800 \frac{G (1 + 0.003665 t)}{(B - \omega) \cdot V}.$$

Now $D = \frac{p}{p_1}$, where p equals the weight of the volume of vapour (V), p₁

the weight of the same volume of air. If the vapour density is taken relatively to hydrogen it is 14.46 D, and since according to AVOGADRO'S law equal volumes of different gases under equal pressures at equal temperatures contain the same number of molecules, and since the gas molecule occupies the same volume as two atoms hydrogen the molecular weight of the vapour is 28.92 D, i. e.:— (14.46 × 2).

B. FROM THE ELEVATION OF THE BOILING POINT. 1 gramme molecule of any substance dissolved in 100 g of the same solvent causes the boiling point to rise by a constant amount. The molecular increases are determined from experiments with compounds of known molecular weight. They can also be determined by means of the formula $0.02 \cdot \frac{T^2}{\omega}$, where T is the absolute boiling point and ω is the latent heat of fusion of the solvent. Constants for 100 g of common solvents are:—

Acetone 16.7°, ethyl alcohol 11.5°; ethyl ether 21.1°; benzene 267°; chloroform 36.6°; acetic acid 25.3°; carbon bisulphide 23.7°; water 5.2°.

For other solvents the constants are determined before the experiment, which, by the way, should also be done with the liquids mentioned.

If g is the number of grammes of the substance per 100 g solution medium, A the rise of boiling point and r the constant for the solvent, then the molecular weight is given by

$$M = \frac{g \cdot r}{A}$$

C. FROM THE DEPRESSION OF THE FREEZING POINT. 1 gramme molecule of any substance dissolved in 100 g of the same liquid always causes the freezing point to be lowered by a constant amount. Molecular decreases can be tested by freezing experiments, or calculated according to the formula $0.02 \cdot \frac{T^2}{\omega}$,
w

where T is the absolute freezing point and ω is the latent heat of fusion of the solvent. Constants:—

Formic acid 28° ; ethylene bromide 118° ; benzene 50° , acetic acid 39° ; naphthalene 70° , nitro-benzene 71° , phenol 76° , thymol 92° , water 19° .

If g denotes the number of grammes of the substance in 100 g solution medium, D the depression found and r the constant of the solvent, the molecular weight is given by

$$M = \frac{g \cdot r}{D}.$$

WACHSMUTH has described an apparatus for determination of vapour density by acoustic means. The vapour brought to a certain temperature blows a whistle connected with the apparatus. There is a comparison whistle, which can be regulated, which indicates the vapour density. It is easy to control the graduation of the test whistle. It is fitted with a scale of oscillations corresponding to the note. The whistle is blown with the lips (in the heater, as the note is influenced by the covering) and the height and oscillations are determined on the comparison whistle. (It should be $a_3 = 1740$.) Then the densities sought are to the density of the air (approximately) inversely as the squares of the oscillations observed. The exact formula is (see BOLTZMANN (celebration) address, Leipsic 1904, page 923):

$$d = \frac{k_x p_x (1 + at_x) n_o^2}{k_o p_o (1 + at_o) n_x^2}.$$

The indices are for air. k denotes the ratio of the specific heats at constant pressure and constant volume (air = 1.4, highly molecular compounds approximately = 1.1), p the pressure (never varying considerably from 1 atm. and very nearly equal in the numerator and denominator), t the temperature and n the number of oscillations. For $t = 100^\circ$ the numerator and denominator of the first part of the fraction practically cancel, so that the formula

$$d = \left(\frac{n_o}{n_x} \right)^2$$

may be used. — If air of another temperature is to be used the experiment whistle must first be tested, the new note determined and the scale of the comparison whistle recalculated for this new value.

Molybdenum and Molybdenum compounds.

1. **MOLYBDENUM** Mo. A. W. 96.03. Obtained from the oxides or the chlorides by heating in a current of hydrogen, by reduction with carbon in the electric furnace, or by the electrolysis of molybdenum dichloride and Na. Attempts have been made to prepare it by the action of molybdenum silicide Mo_2Si_3 on MoO_3 in the electric furnace. The Mo_2Si_3 is obtained by heating MoO_3 with excess of SiO_2 and C.

Molybdenum is a steel-grey powder which fuses at extremely high temperatures to a hard silver-like mass. S. G. 9.1. It is malleable and can be welded. On oxidation it forms first MoO_2 and then MoO_3 : readily soluble in HNO_3 and H_2SO_4 . The carbide, MoC_2 , is obtained by heating the metal with excess of carbon in the electric furnace.

2. **MOLYBDIC ACID**. The oxide MoO_3 and the acid H_2MoO_4 are the most important compounds. The former is obtained by roasting the sulphide or by treating with HNO_3 and then heating the salt which crystallizes out. It is a loose white powder which on heating first becomes yellow and then melts to a deep-red liquid. Very sparingly soluble in water, readily soluble in

alkalies with formation of salts (see POTASSIUM, AMMONIUM, &c. COMPOUNDS).

When HCl is carefully added to solution of the molybdates molybdic acid separates as sparingly soluble crystals.

Molybdenum:

Chemische Fabrik in Fürth G. m. b. H., Fürth, Germany.

Molybdenum compounds:

Chemische Fabrik in Fürth G. m. b. H., Fürth, Germany.

Molybdenum lamps. Electric incandescent filament lamps. See Germ. Pat. 154262.

Monnot metal. Metals joined by autogenous soldering. A steel-block or rod is joined to some other metal by autogenous soldering and the whole further worked. The method is probably attended with difficulties on account of the differences in the coefficients of expansion of the various metals.

Monoazo dyestuffs see "AZO DYE STUFFS".

Monobromcamphor see "BROMCAMPHOR".

Monoketone dyestuffs see "OXYKETONE DYE STUFFS".

Mononitrotoluene see "NITROTOLUENE".

Monotal. The lactic acid ester of guaiacol. A colourless oil sparingly soluble in water, readily in olive oil. Successfully used in cases of neuralgia, &c.

Montan wax. Obtained by distilling in steam the bitumen prepared by extracting sulphurous brown coal with benzene. The commercially pure article melts at 80° and forms a good substitute for ceresine in candle manufacture since it has a high melting point.

Montanine. An almost colourless, odourless liquid containing 31 % of hydrofluosilicic acid. It is recommended as a disinfectant for the walls of breweries, distilleries, &c. On the surfaces treated with montanine the usual moulds do not grow for at least a month after treatment.

Montpellier yellow see "LEAD COLOURS".

Morine see "FUSTIC".

Morphine see "OPIUM AND OPIUM ALKALOIDS".

Montejus.

Montejus of Earthenware:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Montejus of Metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 18, Brückenstr. 6b (see advts.).

Mortars. They are classified into those which harden in air, and those which harden in air and in water; the former are termed air mortars and the latter hydraulic mortars or cements.

In the present article air mortars alone will be considered. (See also "CEMENT".)

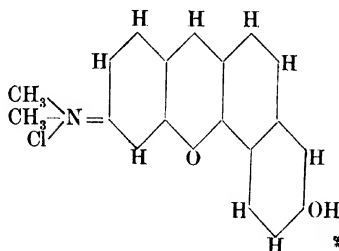
LIME MORTAR is the principal substance used as mortar. It is a mixture of slaked lime and sand; plaster of Paris, sometimes used as mortar, is treated in a special article.

The hardening of mortar depends partly upon the evaporation of the water, but chiefly upon the absorption of CO_2 , the Ca(OH)_2 being converted into CaCO_3 . The sand makes the substance porous so that the carbonic acid of the air can readily enter. Sand also lessens the shrinking of the substance, which otherwise occurs to a considerable extent.

One part of slaked lime stirred with water to form a cream is mixed with 3—4 parts of sand. When mortar is required in great quantities it is mixed by mortar machines instead of by hand. Mortar is also used in the preparation of artificial sand stones.

Fire-proof mortar differs from both air mortar and hydraulic mortar. It is a mixture of dried powdered clay and fire clay with water. It should be observed that this mortar, used particularly for furnaces, &c., though it resists the heat well has but little mechanical strength, since no chemical combination takes place during hardening.

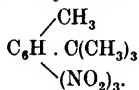
Mucogen. A chlorine derivative of dimethylphenyl p-ammonium β -oxynaphthoxazine



It is obtained by the condensation of dinaphthol with nitrosodimethylamine. Mucogen forms blue crystals sparingly soluble in water, readily soluble in alkalies. It is prescribed for the removal of mucus in the intestines and it also acts as an aperient.

Muriatic acid see "HYDROCHLORIC ACID".

Musk (ARTIFICIAL). Trinitrobutyltoluene.



Tertiary butyltoluene is obtained by the action of isobutylchloride on toluene in the presence of Al_2Cl_3 . It also occurs in a fraction (170—200°) obtained during the distillation of resin oil (q. v.). From the butyltoluene the nitro-compound is obtained by the action of 1 part HNO_3 (S. G. 1.5) and 2 parts fuming H_2SO_4 (15% SO_3) at 100°. The product is poured into water and the trinitro compound recrystallized from alcohol. Yellow needles, M. P. 96—97°.

Muskone is the active constituent of the natural perfume. It is a ketone and may be obtained by distilling musk with steam (Germ. Pat. 180719). It is a colourless oil with a fine odour of musk.

Myogen. A food preparation consisting of pure albumen obtained from the blood serum of freshly slaughtered cattle. It contains 13.32 % nitrogenous matter corresponding to 83.25 % albumen.

N

Nalicine. A new local anaesthetic used in dentistry. It contains 1% nitroglycerine solution, thymol, H_2O , NaCl, alcohol, formaldehyde, carbolic acid, and 1 g cocaine to every 100 g of the mixture.

Naphalane. A crude naphtha product containing soap. It is similar in properties and uses to naphthalane (q. v.).

Naphtha.**Solvent Naphtha:**

Brotherton & Co. Ltd., City Chambers, Leeds.

Naphthalane. A greasy mass prepared from the high-boiling constituents and residues of the distillation of a naphtha from certain Caucasian naphtha wells. This naphtha is free from resin and asphalt and forms a gelatinous homogeneous mass when treated with 3—4 % of anhydrous soap.

It is a brownish-black or brownish-green substance with a green fluorescence. M. P. 65—70°. Insoluble in water, alcohol and glycerine, soluble in ether and chloroform and miscible with all kinds of oils.

It has been used with good results in various skin diseases, and for burns and other injuries. It is readily absorbed by the skin and is a good medium for many medicaments.

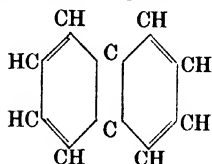
Naphthalene. $C_{10}H_8$. The product of the dry distillation of many organic substances and a constituent of coal tar (q. v.). It is obtained from various fractions of the latter, e. g. from light oil, creosote oil (heavy oil), though chiefly from carbolite oil (see "PHENOLS"). From all these fractions crude naphthalene separates in a crystalline form on cooling; the oils which remain liquid are drawn off and the naphthalene obtained by pressing or centrifuging. The presses which remove a large amount of impurities are usually heated with steam. The crude naphthalene is washed with soda lye (15—20° Bé) and then with concentrated H_2SO_4 (S. G. 1.84) and finely powdered pyrolusite (5 % of the weight of crude naphthalene). Finally, if the quantities are small the naphthalene is sublimed, or, if large, distilled in shallow wrought iron retorts.

The French Pat. 326163 deals with a process and plant for the crystallization and rapid separation of naphthalene and anthracene from the mother liquors. The arrangement consists of a revolving drum, cooled internally, over which the crude oil runs and solidifies. The crystalline substance is removed from the drum by scraping, and is then filtered and finally pressed or centrifuged.

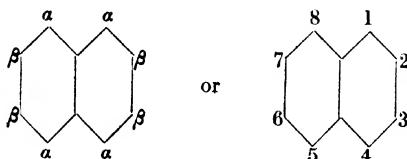
The Engl. Pat. 25989 (1903) treats of the mechanical purification of crude naphthalene by sublimation or distillation. A current of air is allowed to act on the naphthalene vapours, the naphthalene is condensed while the more volatile vapours of the impurities are carried away by the air current. — The method probably effects only a preliminary purification. Chemically pure naphthalene can scarcely be obtained by this method.

The Engl. Pat. 17641 (1903) proposes the application of the "SWEATING" method in general use in the paraffin industry, to the purification of naphthalene. Crude naphthalene in blocks and lumps is heated nearly to the M. P. on perforated trays, when the impurities having lower M. P. run off. The naphthalene can be afterwards further purified by chemical means. The preliminary purification saves a considerable quantity of chemicals.

The constitution of naphthalene is represented thus:—



In the derivatives the position of substituted groups is indicated by either of the following schemes:—



Pure naphthalene forms colourless crystalline leaves, often with a silvery lustre, of penetrating smell; insoluble in H_2O , easily soluble in alcohol, ether and oils. M. P. 79° ; B. P. $217-218^\circ$, though volatile at the ordinary temperatures and readily in steam. Naphthalene is used in the manufacture of numerous tar-colours, phthalic acid, soot, cart-grease, naphthalene varnishes (the application for a patent on the latter has been withdrawn), also for carburetting coal gas, and for medical purposes; it is also used as a disinfectant and as a preventive against the attacks of moth. A new application found is to render non-inflammable and non-explosive the celluloid made from artificial camphor. See "CELLULOID".

TEST. Naphthalene as it is now sold is almost chemically pure. It must be perfectly white, volatile without residue, melt at 79° exactly and distil nearly completely within one degree. It should dissolve in petroleum benzene to a colourless, water-clear liquid, should not become yellow when exposed to the air or light, and should colour concentrated H_2SO_4 only a faint pink. In testing naphthalene for its behaviour towards air and light, samples placed on watch-glasses over pure concentrated (not fuming) HNO_3 should remain colourless for at least 1—2 hours. After a few hours pure naphthalene becomes yellow when placed over HNO_3 owing to the formation of nitro-derivatives.

Impure naphthalenes contain slight traces of phenols; they are extracted with soda lye, the solution supersaturated with HCl and the acid filtrate of the solution mixed with bromine water, when the phenol is precipitated as tribromophenol. (See the test for "PHENOL".)

Naphthalene:

Brotherton & Co. Ltd., City Chambers, Leeds.
Domeier & Co., 8 Harp Lane, London E.C.

Naphthalene derivatives see "NAPHTHOLS", "NAPHTHOL DERIVATIVES", "NAPHTHYLAMINES" and "NITRONAPHTHALENE".

Naphthenes. Certain hydrogen derivatives of the aromatic hydrocarbons, e. g. hexahydrobenzene C_6H_{12} .

Naphthionic acid see "NAPHTHYLAMINE DERIVATIVES".

Naphthols (Oxynaphthalenes). $C_{10}H_7.OH$. Of the two isomers, α -naphthol and β -naphthol the latter is of the greater importance.

1. α -NAPHTHOL. When fuming H_2SO_4 acts on naphthalene at $80-90^\circ C$ α -naphthalene sulphonic acid is the chief product. By neutralizing with $CaCO_3$ the Ca salt of this acid is obtained and then converted into the sodium salt by $NaOH$. This is then fused with $NaOH$ and the product is sodium α -naphtholate. During the fusion, which is carried out in iron stirring vessels, the substance separates into two layers: at the bottom is the excess of $NaOH$ and the Na_2SO_3 , and above the fused naphtholate gathers. From the latter the naphthol is obtained by adding HCl or better by the action of CO_2 and is then purified by distillation *in vacuo*. The small amounts of β -sulphonic acid formed during the sulphonation are removed before fusion by fractional distillation of the calcium salts. — According to Germ. Pat. 74879 pure α -naphthol is obtained by heating the salts of α -naphthylamine with H_2O ; the α -naphthylamine required is produced by nitrating naphthalene and reducing the nitronaphthalene.

α -naphthol forms colourless crystals with a phenol-like smell. M. P. $95^\circ C$; B. P. $278-280^\circ$. It dissolves sparingly in cold, rather more readily in hot H_2O , very readily in benzene, alcohol and ether. Commercial α -naphthol forms a fused crystalline mass.

2. β -NAPHTHOL. When fuming H_2SO_4 acts on naphthalene at 200° the sole product is β -naphthalene sulphonic acid. This is converted into its Na salt and then treated as in the preparation of α -naphthol, i. e. the Na salt is fused with soda and the free naphthol separated by acids.

According to the Germ. Pat. 134401 β -naphthol (and its derivatives) are obtained by converting β -naphthylamine (and its derivatives) into the sulphonic acid ester of naphthol (or its derivatives) by heating with SO_2 and aqueous solution of bisulphites, or with excess of the latter alone. The ester is then saponified by alkali or by some other means.

β -naphthol, when pure, forms small shining colourless leaves, sparingly soluble even in hot H_2O , readily in alcohol, ether and benzene. M. P. 128° ; B. P. $285-290^\circ$, though it may be sublimed at a much lower temperature. The commercial product is a colourless or yellowish crystalline mass. It is chiefly used in the preparation of various azo-dyes. It is also used medicinally.

TEST. 1. Differences between α - and β -naphthol.

	α -Naphthol	β -Naphthol
a) The aqueous solution is coloured by a solution of bleaching powder: a slight excess of the reagent causes the colour to vanish in the case of β -naphthol.	violet	yellow
b) The aqueous solution mixed with liquid ammonia exhibits fluorescence.	blue	violet
c) The alcoholic solution (1 + 5) is coloured by $Fe_2 Cl_6$.	violet (for a time)	green (permanently)
d) When 0.5 g naphthol is fused with 12 g chloralhydrate for 10 min. on a boiling water bath, the substance turns and dissolves in alcohol with a colour.	red red	blue blue
e) When 0.1 g of vanilline is dissolved in 2 ccm sulphuric acid and then 0.1 g naphthol is added, by shaking a colour is produced which is permanent in the case of α -naphthol.	red	chlorophyll green

2. The presence of α -naphthol and β -naphthol is detected according to E. LEGER by sodium hypobromite: A cold saturated aqueous solution of the substance to be tested is prepared by crushing it in a mortar and filtering the emulsion after standing for a short time. The hypobromite solution is made from 30 ccm soda lye (36° Bé), 100 ccm water and 5 ccm bromine. 10 ccm of the aqueous naphthol solution are mixed with a few drops of the hypobromite solution. In α -naphthol solution a muddy-violet precipitate occurs (the reaction is very sensitive); in β -naphthol solution a yellow colour is observed which gradually becomes greenish and then yellow again. In more dilute β -naphthol solution the yellow colour vanishes with a little shaking. (This reaction is less sensitive than the α -naphthol reaction.) When the saturated solution of both naphthols is mixed with the same volume of water and two drops of hypobromite solution and shaken, the β -naphthol reaction does not take place while the α -naphthol colouring does occur. By this method the presence of 1 % of α -naphthol is easily proved. The solutions used must always be freshly prepared.

3. The test for impurities is identical for both naphthols. The M. P. and B. P. must be right; 0.5 g naphthol when heated must not leave a weighable residue.

4. KUESTER's method is used for quantitative determination of naphthols. (See Berl. Ber. 27, 1101 and 1905.)

Naphthol derivatives. In the following, the various sulphonic-acids are given. The system of nomenclature is given under "NAPHTHALENE".

1. α -NAPHTHOL-SULPHONIC ACID NW. Naphtholmonosulphonic acid 1 : 4 (NEVILLE and WINTHER's acid); produced first by diazotizing naphthionic acid and boiling the diazo compound with dilute H_2SO_4 ; also by the action of bisulphites on naphthionic acid.

2. α -NAPHTHOL-SULPHONIC ACID C (α -naphthol-sulphonic acid L). Monosulphonic acid $\text{OH} : \text{SO}_3\text{H} = 1 : 5$ (CLEVE's acid). It can be obtained by diazotizing 1 : 5- α -naphthylamine sulphonic acid and boiling the diazo compound with dilute H_2SO_4 .

3. β -NAPHTHOL-SULPHONIC ACID S (SCHAEFFER's acid). Monosulphonic acid $\text{OH} : \text{SO}_3\text{H} = 2 : 6$. Obtained according to a patented method by heating 1 part β -naphthol with 2 parts concentrated H_2SO_4 at 100° until soluble in water.

4. β -NAPHTHOL-SULPHONIC ACID B (Croceine sulphonic acid; BAYER's acid). Monosulphonic acid $\text{OH} : \text{SO}_3\text{H} = 2 : 8$. Produced in much the same way as No. 3, by mixing 1 part β -naphthol with 2 parts conc. H_2SO_4 at 50° to 60° C, and immediately pouring into H_2O .

5. α -NAPHTHOL-DI-SULPHONIC ACID 1 : 2 : 4. Obtained by the moderate action of fuming H_2SO_4 on α -naphthol.

6. α -NAPHTHOL- ϵ -DI-SULPHONIC ACID (ANDRESEN's acid). Obtained by various patented methods, e. g. by heating 1 : 3 : 8 naphthylamine-di-sulphonic acid with H_2O to 180° C under pressure.

7. α -NAPHTHOL-DI-SULPHONIC ACID Sch (SCHOELLKOPF's acid). Obtained by sulphonating naphthosulphone (patented method). The constitution is $\text{OH} : \text{SO}_3\text{H} : \text{SO}_3\text{H} = 1 : 4 : 8$.

8. α -NAPHTHOL-DI-SULPHONIC ACID RG. Obtained by fusing naphthalene tri-sulphonic acid with caustic soda (patented process). The constitution is not quite certain, but is probably $\text{OH} : \text{SO}_3\text{H} : \text{SO}_3\text{H} = 1 : 3 : 6$.

9. β -NAPHTHOL-DI-SULPHONIC ACID R (2 : 3 : 6). It is formed together with the G-acid (mentioned in No. 11) by sulphonating β -naphthol (patented method).

10. β -NAPHTHOL-DI-SULPHONIC ACID F (2 : 3 : 7). Usually obtained from 2 : 7-naphthol monosulphonic acid.

11. β -NAPHTHOL-DI-SULPHONIC ACID G (2 : 6 : 8). It is formed with the R-acid mentioned in No. 9.

12. α -NAPHTHOL-TRI-SULPHONIC ACID 1 : 2 : 4 : 7. Obtained by sulphonating α -naphthol (patented method).

13. DI-OXY-NAPHTHALENE SULPHONIC ACID S (OH : OH : SO₃H = 1 : 8 : 4). Obtained by fusing α -naphthol-di-sulphonic acid Sch with caustic soda.

14. CHROMOTROPE ACID, also called chromogen I. Di-oxy-naphthalene-di-sulphonic acid: OH : OH : SO₃H : SO₃H = 1 : 8 : 3 : 6. One patented method of production is to melt α -naphthol-tri-sulphonic acid with caustic soda.

Amido-naphthol-sulphonic acids, see under "NAPHTHYLAMINE DERIVATES".

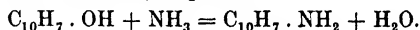
Naphthol Rectifying apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 5b (see advts.).

Naphthylamines (Amido-naphthalenes). C₁₀H₇.NH₂. The two isomers are obtained by entirely different methods.

α -NAPHTHYLAMINE is obtained by reducing α -nitro-naphthalene (q. v.) by the following process:— 800 kg Fe and 40 kg HCl are mixed, water added, the mixture warmed and then 600 kg air-dried α -nitro-naphthalene added with constant stirring and the temperature kept at 70° C. for 6–8 hours. Slaked lime (about 50 kg) is then added until the reaction is alkaline, when the naphthylamine is distilled in retorts, the temperature of the cooling water being kept at 60° C to avoid the choking of the condenser by naphthylamine. The crude naphthylamine solidifying as a blackish-grey mass in the receiver is purified by rectification. It forms colourless leaves, easily sublimed, sparingly soluble in H₂O, readily in alcohol and ether. It possesses a very disagreeable smell. The crystals gradually turn brown when exposed to the air M. P. 50°, B. P. 300°. The commercial, product is, (according to its purity), colourless or brownish-black. — The Germ. Pat. 139457 quoted in the article on "ANILINE" has been extended to the preparation of α -naphthylamine. According to this catalytic method, based upon the addition of hydrogen in the presence of finely divided metals, when the vapours of nitro-naphthalene mixed with H or water gas are passed over a layer of reduced Cu at a temperature of 300–400° C, reduction to naphthylamine takes place smoothly.

β -NAPHTHYLAMINE cannot be produced in the same way since nitration of naphthalene results in the formation of α -nitro-naphthalene. It is obtained by the action of ammonia on β -naphthol:—



10 kg β -naphthol are heated with 4 kg caustic soda and 4 kg sal ammoniac in an autoclave to 160° for 60–70 hours, the unchanged β -naphthol is then removed by treatment with NaOH and the β -naphthylamine extracted from the undissolved residue with dilute HCl. According to a new method, sulphites are added in the process; the sulphuric acid ester of β -naphthol is first formed which is changed more readily than the naphthol itself into the amido compound. — The commercial product is a hard, fused mass, while pure β -naphthylamine forms bright white odourless leaves, sparingly soluble in cold readily in hot H₂O, alcohol and ether. It is volatile in steam. M. P. 112°; B. P. 294°. Both naphthylamines are mainly used in the manufacture of azo-colours.

NAPHTHYLPHENYLAMINE. C₁₀H₇.NH.C₆H₅. It is obtained as the α -modification by heating aniline salt with α -naphthylamine to 240° C. The commercial product is a light brown mass, the pure compound is colourless. M. P. 62°, B. P. (at 15 mm mercury) 226°.

TEST. Commercial α -naphthylamine should melt at 62° and should dissolve completely in warm dilute HCl without leaving any oily residue. A solution of α -naphthylamine hydrochloride gives a violet precipitate with Fe₂Cl₆ and other oxidizing agents. Nitrites in slightly acid solution give a brown-red precipitate of amido-azo-naphthalene.

β -naphthylamine differs from α -naphthylamine in having a much higher M. P. and in the absence of the disagreeable smell. Oxidizing agents do not produce characteristic colour reactions in solutions; with nitrites a brick-red precipitate of β -amido-azo-naphthalene is formed. The commercial product should not smell of α -naphthylamine, should have approximately the theoretical M. P. and should dissolve almost completely in dilute HCl. The chief impurities are naphthol and di-naphthylamine the presence of which may be detected by their insolubility in HCl.

Naphthylamine derivatives. The following are the various sulphonic acids. The system of nomenclature is given under "NAPHTHALENE".

1. **NAPHTHIONIC ACID.** α -naphthylamine sulphonic acid 1 : 4, obtained by the action of hot fuming H_2SO_4 on α -naphthylamine.

2. **α -NAPHTHYLAMINE SULPHONIC ACID L** (naphthalidine sulphonic acid; LAURENT'S acid) $NH_2 : SO_3H = 1 : 5$; obtained by sulphonating α -naphthylamine.

3. **β -NAPHTHYLAMINE SULPHONIC ACID D** (DAHL'S acid). $NH_2 : SO_3H = 2 : 5$. Obtained by the action of 3 parts concentrated H_2SO_4 on 1 part β -naphthylamine sulphate at $15-20^\circ$ for several days (patented process).

4. **β -NAPHTHYLAMINE SULPHONIC ACID Br** (BROENNER'S acid). $NH_2 : SO_3H = 2 : 6$. Obtained by heating β -naphthol-sulphonic acid S 2 : 6 (see "NAPHTHOL DERIVATIVES") with aqueous ammonia in digestors for some time at $180^\circ C$ (patented process).

5. **β -NAPHTHYLAMINE SULPHONIC ACID F** (Delta acid, F-acid). $NH_2 : SO_3H = 2 : 7$. Obtained like No. 4 from 2 : 7 naphthol sulphonic acid.

6. **α -NAPHTHYLAMINE- β -DI-SULPHONIC ACID 1 : 3 : 8.** Obtained by sulphonating naphthalene with fuming H_2SO_4 at the ordinary temperature, followed by nitration and then by the reduction of the nitro-naphthalene-di-sulphonic-acid 1 : 3 : 8 thus obtained.

7. **α -NAPHTHYLAMINE-DI-SULPHONIC ACID D** (DAHL'S acid). A mixture of di-sulphonic acid $NH_2 : SO_3H : SO_3H = 1 : 4 : 6$ (acid II) with di-sulphonic acid 1 : 4 : 7 (acid III). According to a patented method the mixture is made by heating to 120° 1 part α -naphthylamine with 5 parts 25 % fuming H_2SO_4 . To separate the two acids, the calcium salts are prepared, extracted with 96 % alcohol and the undissolved residue treated with boiling 85 % alcohol: the calcium salt of acid II dissolves, while acid III remains undissolved.

8. **β -NAPHTHYLAMINE-DI-SULPHONIC ACID R**, 2:3:6; obtained from β -naphthol-di-sulphonic acid R by treatment with NH_3 (see "NAPHTHOL DERIVATIVES").

9. **β -NAPHTHYLAMINE-DI-SULPHONIC ACID G**, 2:6 : 8 (GANS' acid). Obtained by heating β -naphthylamine sulphate with 25 % fuming H_2SO_4 to $100-140^\circ C$ (patented process).

10. **β -AMIDO-NAPHTHOL SULPHONIC ACID F** $NH_2 : OH : SO_3H = 1 : 8 : 6$. Obtained by melting β -naphthylamine-di-sulphonic acid G with caustic soda.

11. **AMIDO-NAPHTHOL-DI-SULPHONIC ACID H.** $NH_2 : OH : SO_3H : SO_3H = 1 : 8 : 3 : 6$. Obtained by heating the 1 : 8 : 3 : 6 di-amido-naphthalene-disulphonic acid with dilute acids to $100-120^\circ$.

Naphthylphenylamine see "NAPHTHYLAMINE".

Naples yellow see "LEAD COLOURS".

Narceine see "OPIUM" and "OPIUM ALKALOIDS".

Narcoform see "SOMNOFORM".

Narcotil. Methylene chloride CH_2Cl_2 . It is used as a local anaesthetic.

Narcotine see "OPIUM" and "OPIUM ALKALOIDS".

Nareyl = Ethylnarceinhydrochloride. $C_{25}H_{31}ON_8 \cdot HCl$. It forms silky prisms M. P. 205—206°, readily soluble in H_2O . It is used medicinally to relieve fits of coughing. The usual doses are 0.06 g internally and 0.02 g subcutaneously.

Natural dyestuffs see "VEGETABLE DYESTUFFS" and "ANIMAL DYESTUFFS".

Negro powder see "SAFETY EXPLOSIVES".

N neodmium see "DIDYMIUM".

Nernst lamps. Electric incandescent lamp in which the incandescent substance is not a carbon filament but one composed of magnesia mixed with incandescent minerals. These oxides being conductors of the second class, do not conduct below 600—800°. The incandescent substance must therefore be previously warmed. This is effected by a heating coil, made incandescent by the current, and automatically switched out when the filaments becomes incandescent. The filament emits a brilliant white light similar to daylight, and at this temperature is a good conductor of electricity.

Nernst lamps are made in various forms — from 16—250 candle powers —: Model A resembles the arc lamp, B the electric incandescent lamp. The Nernst lamp does not require an evacuated globe like the usual carbon filament lamp.

Although the initial cost of Nernst lamps is higher than that of carbon incandescent lamps, they work at a much lower rate.

Nerol. $C_{10}H_{17}OH$. A terpene alcohol isomeric with geraniol (q. v.) present in small quantities in oil of orange. It is obtained from petitgrain oil (French Pat. 326658) or is synthetically prepared (French Pat. 329529). It is also present in the reaction mixture obtained when linalool is acetylated.

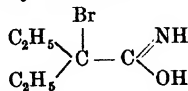
Colourless oil with a pleasant rose-like odour. S. G. (at 15°) 0.880—0.885. B. P. (760 mm) 225—226°. B. P. (25 mm) 125°.

Nerolin. (β -naphtholmethyl ester) $C_{10}H_7 \cdot O \cdot CH_3$. The β -naphthoethyl ester is also known under this name. It is prepared by heating 5 parts β -naphthol, 5 parts of absolute methyl (or ethyl) alcohol and 2 parts H_2SO_4 to 125° for several hours under reduced pressure. It is also obtained by the action of methyl (or ethyl) iodide on potassium β -naphtholate $C_{10}H_7 \cdot OK$. A crystalline substance with an odour like that of orange flowers.

Neurodine = Acetyl-p-phenylurethane. $C_6H_4(CO_2 \cdot CH_3)NH \cdot CO_2 \cdot C_2H_5$. According to the Germ. Pat. 69328 and 73285 the p-oxyphenylurethane is first produced by the action of the ester of chloroformic acid on p-amidophenol and this is converted into neurodine by acetylation with acetic anhydride.

Colourless crystals M. P. 87°, sparingly soluble in cold, a little more readily in hot H_2O . It is chiefly used as an anti-neuralgic, and also as an antipyretic.

Neuronal = Bromdiethylacetamide.



To prepare neuronal diethylacetic acid is converted into diethylacetyl chloride by phosphorus pentachloride. By gradually adding one molecule of bromine the bromdiethylacetyl chloride is formed. This is purified by fractional distillation and changed into bromdiethylacetamide by aqueous ammonia.

Colourless crystals M. P. 66—67° C, soluble in alcohol, ether and benzene. Neuronal has good effects in most cases of insomnia, headache, and epilepsy (it contains 41 % bromine). Dose 0.5—1.0 g.

Neurotropine = Urotropinemethylene citrate. It is used medicinally like urotropine; see "HEXAMETHYLENETETRAMINE".

New Red process see "TURKEY RED DYEING".

Nickel. Ni. Atomic weight = 58.9. The most important nickel ores are kupfernickel NiAs , NiAs_3 , nickel glance NiAs_2 , NiS_2 , breithauptite NiSb , and various silicates such as garnierite with 10—20 % nickel and rewdanskite with 16—18 % nickel. The metal is obtained partly by dry and partly by wet methods. Nickel silicates are smelted with coke and basic substances with formation of crude nickel containing coal and iron; it is decarbonised in MARTIN-furnaces with a hot blast so that Fe, Mn and Si form slags. In obtaining metal from Ni-ores containing sulphur it is important to notice that Ni has greater affinity for S than Fe has, but less than Cu, while the affinity for O is in the reverse order. Consequently so long as there is sufficient S nickel collects together with Cu as matte, from which it is obtained as crude nickel after repeated roasting and smelting operations similar to those used in copper smelting (see "COPPER"). Since the sulphur compounds of Ni and Co are not so stable in presence of C and H as iron and copper pyrites they form slags rather more readily (particularly Co.) When nickel and cobalt compounds containing oxygen are smelted with iron pyrites and acid silicate slags, the Ni (also that of the silicate) goes to the matte almost completely, while the Co does so only partially and the silicate not at all. The nickel ores containing sulphur must be roasted before smelting to remove part of the iron sulphide; they are then melted in the manner mentioned to remove the other metals as slags. On the other hand ores containing arsenic are smelted and roasted, and from this the Ni, concentrated by the roasting and smelting processes, is obtained.

These concentrated materials are further treated by either dry or wet processes. In the former case the process for matte and speiss is similar to the treatment of copper (q. v.) while the crude speiss is refined; the As is removed by various operations and the oxides reduced in closed vessels by charcoal powder. In other cases, nickel from matte and speiss and particularly from the oxide ores is better prepared by the wet method. The ores, roasted or otherwise, are treated with HCl or H_2SO_4 and the lyes freed from the impurities one by one (Cu, As, Sb, Pb, Bi, Fe and Co) by the action of various reagents. The Ni is finally precipitated in boiling solution with soda or milk of lime. These purification processes are similar to the various reactions of analytical chemistry; the most difficult is the complete separation of Ni and Co. See "COBALT".

The crude nickel produced by one or other of these methods, is finally refined, that is, in the first instance C, Si and O are removed. The first two are removed by a process of puddling or by "blowing" in a BESSEMER converter while the O is removed by heating with Al, P, Mn, or more usually with Mg. The removal of O is very important as then the cast nickel is much more ductile and malleable. The Engl. Pat. 19914 (1902) protects a method for refining Ni by melting the crude metal in cupola furnaces.

The MOND process has now advanced beyond the experimental stage. This process, invented by MOND (Germ. Pat. 57320) has for its object the production of refined nickel direct from the ores, by making use of the gaseous nickel carbonyl. The process is as follows: The ores (2—6 % Ni and 2—6 % Cu and Fe are the most favourable compositions) are first roasted, then melted

to a matte which is concentrated in converters. The matte containing 31.37 % Ni, 48.6 % Cu and 0.7 % Fe is ground, roasted, and extracted. The nickel carbonyl is formed by reducing the nickel oxide by reducing gases at 350–400° and conducting carbon monoxide over it at a lower temperature (not above 100° C); the gaseous nickel carbonyl escapes. The vapours are caught and heated to 150–180° when they decompose completely. Pure metallic nickel is formed and CO escapes; the latter can be used to prepare a further quantity of nickel carbonyl. According to Germ. Pat. 149559 the nickel obtained by reducing the oxide is subjected to high pressure in a strong vessel in presence of CO; the pressure is 2–100 atm. (according to the temperature) and the contents of the vessel are heated to 50–250° C. The vapours of the nickel carbonyl mixed with the excess of CO are led through strongly heated pipes where metallic Ni is deposited while the CO is used to treat a further quantity of spongy nickel. The vapours may also be taken through a cooled condenser; the nickel carbonyl then separates as a liquid from which metallic nickel may be obtained.

Attempts have been made to obtain nickel by the reduction of the oxides with carbon in the arc of an electric furnace. The Germ. Pat. 151964 protects a method for the preparation of nickel oxide suitable for this purpose which is free from impurities.

The preparation of nickel from alloys of Ni and Cu, obtained from nickel-copper mattes, has recently been accomplished electrolytically. The Cu is first separated from the alloys electrolytically; the alloys are used as anodes and copper sheets as cathodes; the bath is a solution of copper chloride and nickel chloride. The solution is kept at the proper concentration by continually passing it through a tower containing the granulated Ni-Cu-alloy. During electrolysis the Cu separates while the Ni remains dissolved, so that the electrolyte gradually becomes richer in Ni. When the concentration is sufficiently great Fe and Cu are precipitated (the latter by H_2S) and the purified solution electrolyzed between anodes of carbon and cathodes of sheet copper. The Ni now settles on the cathodes. The Cl evolved at the anodes is conducted into the above mentioned tower containing the granulated alloy through which the solution passes and is used again to dissolve fresh quantities of metal.

E. GUENTHER has made experiments for working directly with concentrated nickel matte (electrolytically). He used anode plates of matte with 75.9 % Ni, 23.9 % S, 0.4 % Fe, 0.16 % Cu and 0.1 % SiO_2 ; the bath was a solution of $NiSO_4$ with 0.03 to 0.25 % free acid. The best current density is given as 250–275 amp. per square meter at 3 volts. The current power is utilized at the rate of 80–92 %. The anode residue was S (80 %) and undissolved metallic sulphates equalling 28 % of the anode material consumed. The nickel obtained was 99.71 % Ni, 0.20 % Cu and 0.085 % Fe.

Ni is a greyish-white metal of high silvery lustre, soft and capable of taking a polish, malleable, magnetic; it is approximately as ductile as and stronger than Cu. S. G. 8.9; M. P. about 1500° C (lower when it contains C). It is used in the manufacture of various articles, chiefly in the form of alloys (see "NICKEL ALLOYS"). Electrolytic nickel plating is carried out on a large scale (see "NICKEL PLATING").

Nickel bath. A solution of 5–7 % purest nickel salt (nickel ammonium sulphate, absolutely free from Cu) is used; the solution must be absolutely neutral, accurately neutralized with NH_3 . To the bath 2.5 % pure boric acid or 0.5 % citric acid is added; 1–2 % crystallized ammonium sulphate is also frequently added.

If copper plating precedes the nickel plating the current used is 1.2 amp. at 20° C; but for direct nickel plating of copper alloys and iron 0.6 amp.

per square decimetre is used. At first a strong current should be employed to produce a thin covering rapidly, since until then a strong polarization current tends to neutralize the effect of the electrolytical process. In order to alter the current conveniently the nickel plating arrangement is always equipped with a resistance that can be regulated. Nickel baths require 2.0—2.2 volts. Very thick nickel coverings cannot be obtained in cold baths as the deposit peels off. Nickel platings of any thickness may be obtained on zinc sheets — otherwise the most difficult material to plate — by first polishing them very highly and warming the liquid to a temperature between 60 and 90°.

According to a new method by EDISON the surfaces of an iron or steel article are first plated very thinly and then heated to the M. P. of Ni in a non-oxidizing atmosphere, e. g. hydrogen. The nickel film thus fused on to the metal is said to adhere so firmly that neither stretching nor minting will cause it to break away.

Nickel alloys. Since it was discovered how to free nickel from C, Si and O (see "NICKEL") the difficulties of working with pure nickel have been overcome. In consequence of these difficulties the greater part of this metal is still used in the form of its alloys, chiefly with copper. An especially fine white colour is possessed by an alloy of 3 parts Ni and 4 parts Cu, though this is also very difficult to work. The German nickel coins consist of 25 % Ni and 75 % Cu. Other nickel alloys are:—

1. GERMAN SILVER (Argentane, Maillechort, Pakfong, Alpacca, White Copper). The most important of all Ni-alloys, consisting of Ni, Cu, Zn in very varying proportions, on an average 16 parts Cu, 7 parts Zn and 48 parts Ni. According to the composition it is yellowish-white to silver white in colour; it is very resistant to chemical action and harder than brass. It is usually obtained by melting the ingredients together in graphite crucibles. Since As makes German silver brittle and less easily worked, the purity of the components is of great importance. When the alloy contains a little Ag it is called Chinese silver (Peru silver) while silver plated German silver is known as ALFENIDE, ARGYROIDE and CHRISTOFLE.

2. NICKEL IRON and NICKEL STEEL see "IRON ALLOYS".

3. MINARGENTUM. Very hard alloy, similar to silver in colour and lustre. 70 parts Ni, 100 parts Cu, 5 parts W and 1 part Al.

4. NICKELINE. Alloy similar to German silver, used for electric resistances. Composition variable, e. g. 54 % Cu, 26 % Ni, 20 % Zn. Specific resistance $\alpha = 0.0002$. Since the resistance of German silver changes in the course of time, nickel alloys free from Zn are frequently preferred, like *Constantane* (see below) and *Manganine* (see "MANGANESE ALLOYS").

5. NICKEL ALUMINIUM. A new alloy of Ni and Al which is apparently becoming important for bell casting. Nickel aluminium with a tensile strength of 13.8 kg per square mm has a S. G. of 2.8, while the metals otherwise used for bells, like cast steel and bronze, have a S. G. of 7.8 and 8.8 resp. This should be a considerable factor in the construction of towers which suffer considerably from the effects of the swinging of the bells. The bells of nickel aluminium are said to have quite as pure a tone as those made of bronze though the tone is a little softer. They are also very resistant to atmospheric agencies since oxidation is impossible. See also "ALUMINIUM ALLOYS" No. 7 and 8.

6. CONSTANTANE. Material for electric resistances, consisting of 50 % Cu and 50 % Ni. Specific resistance $c = 0.5$; temperature coefficient $\alpha = 0.000025$.

7. ROSEINE. Alloy, used by jewellers, consisting of 40 parts Ni, 30 parts Al, 20 parts Sn and 10 parts Au.

8. INVAR. Alloy of 36 % Ni and 64 % steel. It scarcely expands at all on heating and so it is very suitable for delicate instruments, measures, and

measuring wires for geodetical surveying, &c. The discovery is due to Dr. GUILLAUME of Paris.

Nickel compounds.

1. NICKEL ACETATE. $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$. Obtained by dissolving nickel oxide in acetic acid. It crystallizes with 4 H_2O ; the apple-green crystals effloresce slightly in air, dissolve in 6 parts cold H_2O and are insoluble in alcohol.

2. NICKEL AMMONIUM SULPHATE see No. 7.

3. NICKEL CHLORIDE. NiCl_2 . It is formed when Ni is dissolved in *Aqua regia*; it sublimes in yellow crystalline scales. Germ. Pat. 146363 treats of a method for obtaining nickel ammonium chloride $\text{Ni}(\text{NH}_4)_2\text{Cl}_2 + 4 \text{NH}_3$; based on mixing the respective metallic salts with excess of NH_3 and precipitating the double salt by the addition of a suitable salt. Germ. Pat. 161119 purposes the production of a similar double salt of the formula $\text{Ni}(\text{NH}_4)_2\text{Cl}_2 + 4 \text{NH}_3 + 2 \text{NH}_4\text{Cl}$; nickel oxide or nickel hydroxide is treated with excess of NH_3 and the ammoniacal solution obtained mixed with excess of alkali chloride.

4. NICKEL OXIDE. NiO . It occurs naturally as bunsenite in green transparent octahedra; it is obtained as a green powder by strongly heating the hydroxide, carbonate or nitrate. Nickel hydroxide $\text{Ni}(\text{OH})_2$ is precipitated by alkalis as an apple-green precipitate from solutions of nickel salts; it dissolves in NH_3 giving a blue solution. All nickel salts correspond to nickel oxide.

5. NICKEL SESQUIOXIDE. Ni_2O_3 . It is obtained by decomposing the chlorate or nitrate at as low a temperature as possible. It is a black powder which is converted into NiO by heating. Hydroxide of nickel $\text{Ni}_2(\text{OH})_6$ is formed when Cl acts on $\text{Ni}(\text{OH})_2$ suspended in water; also when a solution of a nickel salt is warmed with an alkaline hypochlorite; it is a voluminous inky-black precipitate. The Amer. Pat. 763053 protects the production of nickel hydroxide from nickel ammonium chloride by washing the latter in a solution of CaCl_2 and heating it. Nearly identical with this is the Amer. Pat. 773636 according to which the same initial materials are used but the NH_4Cl is removed by distillation.

6. NICKEL SULPHATE. NiSO_4 . Obtained by dissolving Ni in H_2SO_4 with the addition of a little HNO_3 . More frequently by dissolving nickel hydroxide — obtained in preparing nickel by wet methods — in dilute H_2SO_4 and evaporating to the point of crystallization. It crystallizes at $15\text{--}20^\circ \text{C}$ with 7 H_2O in dark emerald-green efflorescent crystals; at a slightly higher temperature it crystallizes with 6 H_2O in bluish-green crystals: at 280°C it turns yellow and loses the water of crystallization. It dissolves in 3 parts H_2O and is insoluble in alcohol. It is chiefly used in nickel plating (see "NICKEL PLATING").

7. NICKEL AMMONIUM SULPHATE. $\text{NiSO}_4 + (\text{NH}_4)_2\text{SO}_4 + 6 \text{H}_2\text{O}$. NiSO_4 is dissolved in H_2O rendered acid with H_2SO_4 and the liquid poured into a solution of ammonium sulphate when the greater part of the Ni is precipitated as the double salt. Green crystals, slightly soluble in H_2O ; at 20°C the anhydrous salt requires 17 parts H_2O for solution. It is almost insoluble in ammonium sulphate solution containing sulphuric acid. It is used in nickel plating.

Nickel Compounds:

Willy Manger, Dresden, Germany.

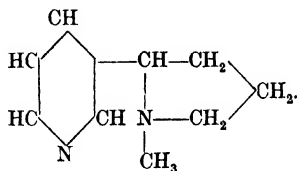
Nickel plating. General information will be found under "ELECTROPLATING". Galvanic nickel plating has become especially important since nickel, in consequence of its resistance to all kinds of external influences, is very suitable for all varieties of metallic articles.

To get a pure white nickel covering, the solution must be slightly acid; as a rule small amounts of boric acid, citric acid, or benzoic acid are added. Nickel sulphate is rarely used. Generally the so-called nickel salt (nickel ammonium sulphate) is preferred as it conducts better. Copper, brass, German silver, and other copper alloys, as well as iron and steel are nickel plated directly, while articles of tin, zinc, Britannia metal and lead are preferably first finely copper-plated or brass-plated before the nickel is applied. The best results are obtained when the articles are previously polished. The anodes are cast or rolled nickel sheets, hung up on either side of the cathode rod (10—15 cm apart). When the articles are round, it is well to surround them with anodes.

Nickel Plating:

Cannings. Great Hampton St., Birmingham.

Nicotine. $C_{10}H_{14}N_2$. This is the alkaloid of tobacco (*Nicotiana tabacum*). The constitution is:



It is best obtained from the tobacco extract usually sold. The latter is diluted, made strongly alkaline with NaOH and then extracted with ether. The alkaloid is separated from the ether by dilute H_2SO_4 ; the aqueous solution of nicotine sulphate is rendered strongly alkaline with NaOH and again extracted with ether. The ether solutions of nicotine are finally dried with solid NaOH, the ether distilled off and the remaining alkaloid rectified in a current of hydrogen.

Nicotine is a colourless mobile liquid. Exposed to air it gradually thickens and becomes brown. It has a strong smell of tobacco and a sharp burning taste; S. G. (at 15°) 1.0147. Nicotine is volatile in steam without decomposition but decomposes if distilled under ordinary pressure. In a current of hydrogen it boils without decomposition at 240—242° C. It is extremely poisonous. It mixes with H_2O , dissolves easily in alcohol, amyl alcohol, ether, $CHCl_3$, petroleum ether and fatty oils.

Nicotine and its salts are used medicinally, internally in doses of 0.001—0.003 g for nervous palpitation of the heart, externally in alcoholic solution for embrocations, poultices, clysters, &c.

Salicylate of Nicotine:

Dr. C. L. Marquart, Chem. Fabrik, Beuel a. Rhein (Germany).

Nigramine. A dyestuff of unknown constitution obtained by the action of nitrodimethylaniline hydrochloride or aniline salts. It is a black powder which dyes mordanted cotton bluish-grey shades.

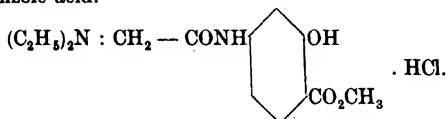
Nigraniline see "ANILINE BLACK".

Nigrisine (New grey). A dyestuff of unknown constitution obtained by the oxidation of amidodimethyl aniline. A greyish-black powder which gives silver grey or dark grey shades on cotton mordanted with tannin.

Niobe oil (Benzoic acid methylester), see "BENZOIC ACID", "FRUIT ESSENCES".

Niobium. Nb. Rare metallic element, atomic weight 93.9. Like its compounds it has no industrial value.

Nirvanine = Hydrochloride of the methyl ester of di-ethyl-glycocol-p-amido-o-oxybenzoic acid.



Mono-chlor-acetyl chloride is allowed to act on the methyl ester of p-amido-o-oxybenzoic acid dissolved in benzene. The benzene is then distilled off, and the chloracetyl-p-amido-o-oxybenzoic acid methyl ester separates out. This is dissolved in alcohol and heated under pressure with a solution of di-ethyl-amine with formation of nirvanine.

White prisms, easily soluble in H_2O . M. P. 185° . Nirvanine is a local anaesthetic; it is used in 0.1—2 % solutions.

Nitraniline. $C_6H_5(NO_2)NH_2$. o-NITRANILINE is obtained as follows (Germ. Pat. 65212): Oxanilide is warmed with H_2SO_4 , the oxanilido-sulphonic acid is nitrated and the di-nitro-oxanilido-sulphonic acid thus obtained is heated with H_2SO_4 at 130 — $150^\circ C$ in open vessels. The oxalyl group is split off and o-nitraniline obtained. Crystals M. P. 71.5° . By nitrating acetyl-sulphanilic acid the same compound is also obtained.

m-NITRANILINE can be produced [Germ. Pat. 30889 (expired)] from aniline: 10 kg finely powdered aniline nitrate is gradually and with constant stirring added to 40 kg of concentrated H_2SO_4 cooled to $-5^\circ C$. The temperature should not rise above $+5^\circ C$. Then the solution is poured into 400 l H_2O , mixed carefully with soda lye, the precipitate washed, pressed, and dissolved in HCl. The m-nitraniline hydrochloride may either be allowed to crystallize or the base may be separated. Yellow crystals, easily soluble in alcohol less so in H_2O ; M. P. 114° ; B. P. 285° .

p-NITRANILINE is obtained from p-nitroacetanilide. The latter is prepared by dissolving acetanilide in hot acetic acid, mixing with H_2SO_4 after cooling the mixture, and then nitrating with a mixture of nitric and sulphuric acids. After standing a short time the mixture is poured into ice-water, when p-nitroacetanilide separates; it is converted into p-nitraniline by warming with dilute H_2SO_4 . According to Germ. Pat. 148749 it is obtained by heating p-nitrochlorbenzene with excess of NH_3 to about 130 — $180^\circ C$; the greater the excess of NH_3 , the lower may be the temperature. p-nitraniline forms yellow needle-shaped crystals, scarcely soluble at all in cold H_2O , readily soluble in hot H_2O , M. P. 147° .

All three nitranilines are used in manufacturing azodyes. p-nitraniline is used in great quantities. p-nitraniline red is produced on the fibre by diazotisation with addition of β -naphthol.

Nitrates see under the respective metallic compounds.

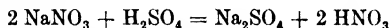
Nitration. Nitration is carried out with nitric acid or fuming nitric acid; with mixtures of concentrated H_2SO_4 (S. G. 1.846) and concentrated HNO_3 (S. G. 1.385—1.440), a mixture called nitration acid; with a mixture of HNO_3 and acetic acid; with potassium nitrite KNO_2 , silver nitrite $AgNO_2$, &c. Instead of $HNO_3 + H_2SO_4$, $KNO_3 + H_2SO_4$ may be used. In general, aromatic substances are nitrated in the cold, as hot HNO_3 has a stronger oxidizing action. Special notes on nitration are given under the methods for obtaining various compounds.

An interesting experiment is the reduction of aromatic nitro-substances in alkaline solutions, a method protected by the French Pat. 314699. With Fe and soda lye nitrobenzene is said to be reduced to hydrazobenzene with great ease, α -nitronaphthalene to α -naphthylamine, &c.

Plants and Apparatus for nitrating:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Nitric acid. HNO_3 . The only important commercial method of manufacture is the one in which Chili saltpetre and H_2SO_4 are used. The reaction is in accordance with the equation



and only takes place at such a temperature that part of the HNO_3 is decomposed into N_2O_4 and O. At lower temperatures NaHSO_4 is formed and twice the amount of H_2SO_4 is used: $\text{NaNO}_3 + \text{H}_2\text{SO}_4 = \text{NaHSO}_4 + \text{HNO}_3$. The reaction, carried out at a moderate temperature, is, however, accompanied by many secondary reactions by which part of the HNO_3 is decomposed into N_2O_4 and O. As this decomposition is generally due to the dehydrating action of concentrated H_2SO_4 , the latter is usually taken not at 66° Bé but at 60° Bé, and an excess (about 20—50% over the theoretical amount) is used, and only when HNO_3 of S. G. 1.5 is required, is H_2SO_4 of 66 Bé used.

The decomposition of NaNO_3 by H_2SO_4 was formerly carried out in glass retorts, but at present cast iron or earthenware retorts in the shape of horizontal cylinders, vats and pots are exclusively used. At the lowest point of the retort there is a tap by which the NaHSO_4 remaining liquid can be drawn off.

The arrangement for condensation consists of a number of earthenware condensation vessels and cooling coils; a cooler is placed between each two condensers. From each set (condenser — coil — condenser — coil — condenser) the acid there condensed can be tapped off by hydraulic means, so that a separation of the colourless from the red acid (containing N_2O_4) may be effected. From these receivers the vapours enter a condensing tower, fed with H_2SO_4 or with H_2O , so that, in the former case nitric acid (which can be used for the manufacture of H_2SO_4) is obtained and weak HNO_3 in the latter. Formerly the use of a coke tower, still used to a small extent, was general, but at present the far more effective and much smaller absorption towers filled with balls, dishes, &c. of earthenware are more frequently employed. HNO_3 is also frequently condensed in large earthenware condensing tubes cooled by air (similar in their arrangement to the air condensers of gas works), from which the uncondensed vapours pass to the absorption tower. GUTTMANN's patented device for condensing nitric acid is of such a nature that the gases coming from the decomposition retorts are rapidly condensed in long earthenware pipes at a temperature at which the greater part of the nitrous acid and the chlorine remain volatile and enter an absorption tower. By an ingenious arrangement the condensed acid is at once removed from contact with the gases; the gases are continuously supplied with air by an automatic apparatus which converts the nitrous acid into HNO_3 , partly in the retorts, and partly in the tower while the chlorine is forced out.

In the manufacture of HNO_3 the formation of N_2O_4 can never be quite avoided; the yellow (red) acid is decolorized by air which is forced in, or compressed air is led directly into the gaseous mixture of HNO_3 , N_2O_4 and H_2O as it leaves the retort.

As mentioned above, the strength of the HNO_3 depends on the concentration of the H_2SO_4 . If the latter is of 60° Bé the HNO_3 obtained is of 40 to 42° Bé (S. G. 1.38—1.41), while the preparation of concentrated HNO_3 requires H_2SO_4 of 66° Bé, and also under certain conditions (for HNO_3 of

S. G. 1.52) sharply dried, chlorine-free Chili saltpetre. In order to concentrate weak nitric acid it is distilled with H_2SO_4 of 66° Bé in VALENTINER's vacuum apparatus. The acid reaches a high percentage (1.5 S. G. = 48° B and higher) and is perfectly white and free from impurities. The latter fact is the reason for its great value in nitrating. The H_2SO_4 during the distillation is reduced in strength to 60° Bé and is then used for the decomposition of fresh saltpetre.

Though in principle the manufacture of nitric acid is extremely simple, in practice there are various difficulties due to the requirements as to the purity of the nitric acid insisted upon by explosive works. WINTERER has studied the principles of the manufacture of nitric acid (Chem.-Ztg. 1905, 820) and gives the results of his investigations as follows:—

In order to obtain nitric acid of the highest concentration and at the same time to obtain a good yield it is necessary that:—

1. The temperature of distillation should be kept as low as possible.
2. No overheating of the contents of the retort should occur.
3. The heating should take place so slowly that overheating becomes impossible. Size and shape of the retorts determine the necessary time in consequence of the varying heat conduction.
4. The best yield of nitric acid of the highest concentration is not obtained by the use of H_2SO_4 of highest concentration and dry saltpetre, but with H_2SO_4 of about 92 %.
5. The introduction of atmospheric oxygen into the retort increases the yield of concentrated acid.
6. Rapid cooling of the distilled gases is of advantage.

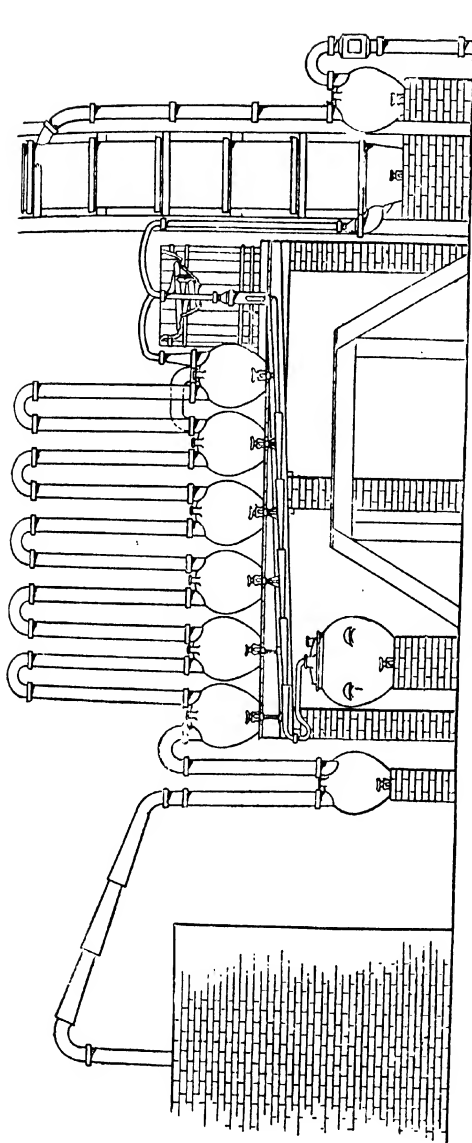
The crude HNO_3 is, as already pointed out, decolourized by a warm current of air, the acid itself becoming warm during the process. By this method not only N_2O_4 (and N_2O_3) but also the additional Cl (from the NaCl of the NaNO_3) are driven off. Absolutely pure HNO_3 is produced from pure H_2SO_4 with dry NaNO_3 , purified by washing.

Various new methods for the production of nitric acid have been introduced during the last few years. In the first instance GUTTMANN and VALENTINER should be mentioned. In GUTTMANN's process (Germ. Pat. 63799, 73421 and 136679) as remarked above air is blown into the gases escaping from the saltpetre retorts, while according to VALENTINER (Germ. Pat. 63207 and 88321) distillation *in vacuo* is required; in this way a colourless acid of S. G. 1.5 is obtained directly without a decolourizing process. In VALENTINER's system a condensation tower is not required. According to Germ. Pat. 144633 of the same firm, pure HNO_3 of the highest degree of concentration is obtained *in vacuo* by adding only $\frac{1}{2}$ of the necessary amount of H_2SO_4 and allowing the rest to flow in at the same rate as the HNO_3 is removed. The H_2SO_4 meets the escaping nitrous gases thus freeing them from H_2O and impurities. In this way 100 % HNO_3 is said to be obtained in one operation.

UEBEL's method (Germ. Pat. 106962) consists of the continuous production of HNO_3 by decomposing saltpetre with polysulphates instead of with H_2SO_4 .

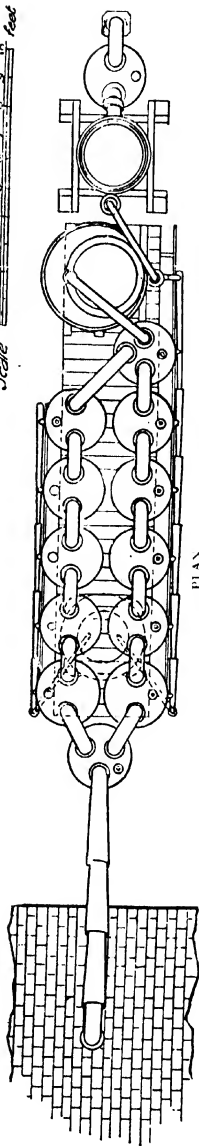
According to NIEDENFUHR (Germ. Pat. 155095) the arrangement for producing HNO_3 is such that the centre is occupied by a contrivance exerting simultaneous a forcing and sucking action; this arrangement exerts suction on the producing retorts and on the first condensing apparatus, and pressure on those parts of the plant in which the oxidation and condensation of the lower oxides of nitrogen are performed.

The Germ. Pat. 155006 treats of the purification of nitric acid by distillation. Nitric acid is made to flow over siliceous matter, &c. placed in distilling vessels heated from the outside. The acid should evaporate before coming in contact with the walls of the vessel and then be condensed in the usual way. A vessel of about 0.5 m height and 0.4 m diameter should turn out about 400 kg



SIDE ELEVATION

Scale 0 1 2 3 4 5 6 7 8 9 10 Feet



PLAN

NITRIC ACID APPARATUS
(Doulton & Co., Ltd., Lambeth)

chemically pure HNO_3 in 24 hours. Bisulphate, compounds of iron, silicic acid and other non-volatile contaminations remain in the vessel. In order to concentrate the dilute HNO_3 obtained by various chemical processes it is mixed with conc. H_2SO_4 and the conc. HNO_3 separated by distillation. There are various objections to this process and many modifications have been introduced. An improvement is that of French Pat. 358373 according to which the dilute acid is heated with polysulphates instead of with H_2SO_4 . In this way conc. HNO_3 and a hydrate of the polysulphate are obtained. The latter on heating to 230° loses water and may be employed for heating a further quantity of HNO_3 . Similar to this is Germ. Pat. 174736.

According to French Pat. 371797 nitrates (e. g. $\text{Ca}(\text{NO}_3)_2$ and $\text{Mg}(\text{NO}_3)_2$) which readily take up water are suitable for the concentration of dilute HNO_3 . Germ. Pat. 180052 proposes concentrating HNO_3 by electrolysis.

Concerning the manufacture of nitric acid from atmospheric nitrogen, see below. —

Red, fuming nitric acid, i. e. a saturated solution of N_2O_4 in crude HNO_3 (S. G. above 1.4) is obtained by distilling KNO_3 (or NaNO_3) with little H_2SO_4 at high temperatures, in order to increase the reduction of HNO_3 to N_2O_4 . The saltpetre is generally mixed with a little starch-powder.

At present attempts are being made from various standpoints to break with the old method of preparing nitric acid from saltpetre. Methods for obtaining HNO_3 from ammonia on the one hand and from the air on the other, have recently become more important than might have been expected. These attempts are justified, for in assuming the same increase of consumption of saltpetre as there has been up till now, it cannot be denied that the deposits of Chili saltpetre will be exhausted in less than 20 years' time.

OSTWALD'S method of obtaining HNO_3 (Engl. Pat. 698, 1903) is to pass a mixture of ammonia and air over a red hot contact substance. The catalytic agent is finely divided platinum or some other platinum metal. In order to prevent overheating the contact substance, pure platinum-black should not be used but either platinum partly covered with platinum black, or only solid platinum. The mixture of air and ammonia may be obtained by bringing air into contact with a solution containing ammonia, the air passing in the opposite direction to the ammonia solution. The solution can be heated by utilizing in some practical way the heat generated by the catalytic reaction. Meanwhile other publications concerning OSTWALD'S method have appeared:— The air supply should be very abundant, the temperature of reaction should be kept above 300°C , the gases should pass through the contact substance as rapidly as possible and, according to the principle of counter currents, should be warmed by those gases which have already passed the contact substance. The apparatus consists of an open tube into one end of which the contact material is placed. This tube is inside a cylinder. The latter is supplied with an opening (near the outlet for the gases from the apparatus) into which the gas mixture is conducted. The gas mixture is thus warmed in the tube which it at first surrounds and through which it finally passes.

According to French Pat. 335229 the mixture of NH_3 with air should be conducted over Fe_2O_3 or some other suitable oxide at 700°C . The N_2O_5 obtained is then converted into HNO_3 by H_2O or into the corresponding nitrate by the use of some suitable oxide.

Still more interesting and important than these two methods are the processes by which HNO_3 is obtained from the air by electrical means. For as NH_3 and HNO_3 bear a certain relation to one another, NH_3 will become scarce when the supply of NaNO_3 runs short. A real solution of the problem is therefore only possible by making use of the inexhaustible resources of atmospheric nitrogen.

The principle of the method, to oxidize atmospheric nitrogen by electricity, has long been known, but it was believed that the current used was too large compared with the amount of HNO_3 formed to make feasible a practical method. Recently, however, methods of this kind have been used in practice. At first the method of BRADLEY and LOVEJOY which made use of the energy of the Niagara Falls was introduced. According to this method (Engl. Pat. 8230, 1901) HNO_3 is produced in a mixture of equal parts of oxygen and nitrogen or simply in air at 80°C by electrical discharges. It is essential that the spark should have as large a surface as possible in relation to a small quantity of energy. According to Chem.-Ztg. 1903, Rept. 152 a continuous current of 10 000 volts should be employed. The negative pole is formed by a perpendicular axis, bearing 6 ray-like arms at 33 points; the positive poles are arranged on the circumference of an iron cylinder forming the reaction chamber. The axis revolves 500 times per minute making and breaking 414000 arcs in the same space of time. The rapid rotation of the axis together with a current of air forced through the cylinder under great pressure produces an intense cooling which prevents what would otherwise take place at a higher temperature, i. e. the dissociation of the HNO_3 formed, so that the escaping air contains only 2—3 % of nitric oxide. As the experiments show that 15.5 H. P. hours are necessary to produce 1 kg nitric acid it was believed that this method would prove lucrative, at least when the power of the Niagara falls was utilized. This, however, was not so; the undertaking had no success and the product was more expensive than that obtained from the natural Chili saltpetre.

Then KOWALSKI's method became known (Amer. Pat. 754147) according to which atmospheric nitrogen is fixed by means of an alternating current of high voltage (up to 50 000 volts). This process also does not appear to be profitable, at least the trial station has ceased to work.

The greatest hope may be set on a method put forward by two Norwegians, BIRKELAND and EYDE. It is protected by Amer. Pat. 772862 and 775123, Norweg. Pat. 13280 and 13240 (1903) Norweg. Pat. 14209 (1904) and numerous others. In connection with this interesting process the following account is taken from a paper by WITT (Prometheus XVII, 129 et seq., 149, 165). It has been known for some time that the arc of an alternating current of moderate E. M. F. under the influence of a magnetic field assumes the shape of a disc. The forces in the field are constantly attempting, so to speak, to blow out the flames as soon as they are formed. A series of flames passing in two directions is thus produced which unite, as far as the eye can detect to a quietly burning light. BIRKELAND and EYDE have found that this flame drawn or blown aside by the influence of the magnetic field has the property in a very high degree of fixing atmospheric nitrogen. In order to utilize this observation practically the flame disc of the alternating current is placed inside flat fire-proof clay ovens lined with copper, through which a powerful current of air is driven. In the apparatus used large flame discs of 2 m diameter are formed, the normal consumption of energy being 500 kilowatts. The fixing of the atmospheric nitrogen is accomplished on account of the fact that in the electrified air (i. e. a mixture of unused O and N with scarcely 2 % nitric oxide) leaving the ovens, the nitric oxide is converted into nitrogen peroxide by the excess of oxygen. The gases are brought into contact with H_2O , the peroxide gives HNO_3 while fresh amounts of nitric oxide are liberated, which are then capable of forming more HNO_3 . The acid concentrates in the absorption towers to 50 % and is converted into calcium nitrate by neutralizing with limestone. The $\text{Ca}(\text{NO}_3)_2$ is allowed to separate in iron receptacles and is then put on the market. At the present time in the BIRKELAND-EYDE works near Notodden in Norway 1500 kg anhydrous HNO_3 are produced daily. The water power gives 1 HP. at about 12 shillings per annum; the yield varies between 500 and 600 kg anhydrous HNO_3 per kilowatt-year. The

Table of the S. G. of nitric acids of various concentrations at 15° C compared with H₂O at 4°. (After LUNGE and REY.)

S. G. at 15° at 4° (vac- uum)	Réaumur Degrees	Twaddell Degrees	100 weight parts contain					1 lit. contains kg				
			N ₂ O ₅	HNO ₃	acid of 36° Bé	acid of 40° Bé	acid of 48.5° Bé	N ₂ O ₅	HNO ₃	acid of 36° Bé	acid of 40° Bé	acid of 48.5° Bé
1.000	0	0	0.08	0.10	0.19	0.16	0.10	0.001	0.001	0.002	0.002	0.001
1.005	0.7	1	0.85	1.00	1.89	1.61	1.03	0.008	0.010	0.019	0.016	0.010
1.010	1.4	2	1.62	1.90	3.60	3.07	1.95	0.016	0.019	0.036	0.031	0.019
1.015	2.1	3	2.39	2.80	5.30	4.52	2.87	0.024	0.028	0.053	0.045	0.029
1.020	2.7	4	3.17	3.70	7.01	5.98	3.79	0.033	0.038	0.072	0.061	0.039
1.025	3.4	5	3.94	4.60	8.71	7.43	4.72	0.040	0.047	0.089	0.076	0.048
1.030	4.1	6	4.71	5.50	10.42	8.88	5.64	0.049	0.057	0.108	0.092	0.058
1.035	4.7	7	5.47	6.38	12.08	10.30	6.54	0.057	0.066	0.125	0.107	0.068
1.040	5.4	8	6.22	7.26	13.75	11.72	7.45	0.064	0.075	0.142	0.121	0.077
1.045	6.0	9	6.97	8.13	15.40	13.13	8.34	0.073	0.085	0.161	0.137	0.087
1.050	6.7	10	7.71	8.99	17.03	14.52	9.22	0.081	0.094	0.178	0.152	0.096
1.055	7.4	11	8.43	9.84	18.64	15.89	10.09	0.089	0.104	0.197	0.168	0.107
1.060	8.0	12	9.15	10.68	20.23	17.25	10.95	0.097	0.113	0.214	0.182	0.116
1.065	8.7	13	9.87	11.51	21.80	18.59	11.81	0.105	0.123	0.233	0.198	0.126
1.070	9.4	14	10.57	12.33	23.35	19.91	12.65	0.113	0.132	0.250	0.213	0.135
1.075	10.0	15	11.27	13.15	24.91	21.24	13.49	0.121	0.141	0.267	0.228	0.145
1.080	10.6	16	11.96	13.95	26.42	22.53	14.31	0.129	0.151	0.286	0.244	0.155
1.085	11.2	17	12.64	14.74	27.92	23.80	15.12	0.137	0.160	0.303	0.258	0.164
1.090	11.9	18	13.31	15.53	29.41	25.08	15.93	0.145	0.169	0.320	0.273	0.173
1.095	12.4	19	13.99	16.32	30.91	26.35	16.74	0.153	0.179	0.339	0.289	0.184
1.100	13.0	20	14.67	17.11	32.41	27.63	17.55	0.161	0.188	0.356	0.304	0.193
1.105	13.6	21	15.34	17.89	33.89	28.89	18.35	0.170	0.198	0.375	0.320	0.203
1.110	14.2	22	16.00	18.67	35.36	30.15	19.15	0.177	0.207	0.392	0.335	0.212
1.115	14.9	23	16.67	19.45	36.84	31.41	19.95	0.186	0.217	0.411	0.350	0.223
1.120	15.4	24	17.34	20.23	38.31	32.67	20.75	0.195	0.227	0.430	0.366	0.233
1.125	16.0	25	18.00	21.00	39.77	33.91	21.54	0.202	0.236	0.447	0.381	0.242
1.130	16.5	26	18.66	21.77	41.23	35.16	22.23	0.211	0.246	0.466	0.397	0.252
1.135	17.1	27	19.32	22.54	42.69	36.40	23.12	0.219	0.256	0.485	0.413	0.263
1.140	17.7	28	19.98	23.31	44.15	37.65	23.91	0.228	0.266	0.504	0.430	0.273
1.145	18.3	29	20.64	24.08	45.61	38.89	24.70	0.237	0.276	0.523	0.446	0.283
1.150	18.8	30	21.29	24.84	47.05	40.12	25.48	0.245	0.286	0.542	0.462	0.293
1.155	19.3	31	21.94	25.60	48.49	41.35	26.26	0.254	0.296	0.561	0.478	0.304
1.160	19.8	32	22.60	26.36	49.92	42.57	27.04	0.262	0.306	0.580	0.494	0.314
1.165	20.3	33	23.25	27.12	51.36	43.80	27.82	0.271	0.316	0.598	0.510	0.324
1.170	20.9	34	23.90	27.88	52.80	45.03	28.59	0.279	0.326	0.617	0.526	0.334
1.175	21.4	35	24.54	28.63	54.22	46.24	29.36	0.288	0.336	0.636	0.543	0.345
1.180	22.0	36	25.18	29.38	55.64	47.45	30.13	0.297	0.347	0.657	0.560	0.356
1.185	22.5	37	25.83	30.13	57.07	48.66	30.90	0.306	0.357	0.676	0.577	0.366
1.190	23.0	38	26.47	30.88	58.49	49.87	31.67	0.315	0.367	0.695	0.593	0.376
1.195	23.5	39	27.10	31.62	59.89	51.07	32.43	0.324	0.378	0.715	0.610	0.388
1.200	24.0	40	27.74	32.36	61.29	52.26	33.19	0.333	0.388	0.735	0.627	0.398
1.205	24.5	41	28.36	33.09	62.67	53.23	33.94	0.342	0.399	0.755	0.644	0.409
1.210	25.0	42	28.99	33.82	64.05	54.21	34.69	0.351	0.409	0.775	0.661	0.419
1.215	25.5	43	29.61	34.55	65.44	55.18	35.44	0.360	0.420	0.795	0.678	0.431
1.220	26.0	44	30.24	35.28	66.82	56.16	36.18	0.369	0.430	0.815	0.695	0.441
1.225	26.4	45	30.88	36.03	68.24	57.64	36.95	0.378	0.441	0.835	0.712	0.452
1.230	26.9	46	31.53	36.78	69.66	59.13	37.72	0.387	0.452	0.856	0.730	0.466
1.235	27.4	47	32.17	37.53	71.08	60.61	38.49	0.397	0.463	0.877	0.748	0.475
1.240	27.9	48	32.82	38.29	72.52	61.84	39.27	0.407	0.475	0.900	0.767	0.487
1.245	28.4	49	33.47	39.05	73.96	63.07	40.05	0.417	0.486	0.921	0.785	0.498
1.250	28.8	50	34.13	39.82	75.42	64.31	40.84	0.427	0.498	0.943	0.804	0.511
1.255	29.3	51	34.78	40.58	76.86	65.54	41.62	0.437	0.509	0.965	0.822	0.522
1.260	29.7	52	35.44	41.34	78.30	66.76	42.40	0.447	0.521	0.987	0.841	0.534

S. G. at 15° 4° (vacuum)	Reaumur Degrees	Twaddell Degrees	100 weight parts contain					1 lit. contains kg				
			N ₂ O ₅	HNO ₃	acid of 36° B \acute{e}	acid of 40° B \acute{e}	acid of 48.5° B \acute{e}	N ₂ O ₅	HNO ₃	acid of 36° B \acute{e}	acid of 40° B \acute{e}	acid of 48.5° B \acute{e}
1.265	30.2	53	36.09	42.10	79.74	67.99	43.18	0.457	0.533	1.009	0.860	0.547
1.270	30.6	54	36.75	42.87	81.20	69.23	43.97	0.467	0.544	1.031	0.879	0.558
1.275	31.1	55	37.41	43.64	82.65	70.48	44.76	0.477	0.556	1.054	0.898	0.570
1.280	31.5	56	38.07	44.41	84.11	71.72	45.55	0.487	0.568	1.077	0.918	0.583
1.285	32.0	57	38.73	45.18	85.57	72.96	46.34	0.498	0.581	1.100	0.938	0.596
1.290	32.4	58	39.39	45.95	87.03	74.21	47.13	0.508	0.593	1.123	0.957	0.608
1.295	32.8	59	40.05	46.72	88.48	75.45	47.92	0.519	0.605	1.146	0.977	0.621
1.300	33.3	60	40.71	47.49	89.94	76.70	48.71	0.529	0.617	1.169	0.997	0.633
1.305	33.7	61	41.37	48.26	91.40	77.94	49.50	0.540	0.630	1.193	1.017	0.646
1.310	34.2	62	42.06	49.07	92.94	79.25	50.33	0.551	0.643	1.218	1.038	0.659
1.315	34.6	63	42.76	49.89	94.49	80.57	51.17	0.562	0.656	1.243	1.059	0.673
1.320	35.0	64	43.47	50.71	96.05	81.90	52.01	0.573	0.669	1.268	1.080	0.686
1.325	35.4	65	44.17	51.53	97.60	83.22	52.85	0.585	0.683	1.294	1.103	0.701
1.330	35.8	66	44.89	52.37	99.19	84.58	53.71	0.597	0.697	1.320	1.126	0.715
1.3325	36.0	66.5	45.26	52.80	100.00	85.27	54.15	0.603	0.704	1.333	1.137	0.722
1.335	36.2	67	45.62	53.22	100.80	85.95	54.58	0.609	0.710	1.346	1.148	0.728
1.340	36.6	68	46.35	54.07	102.41	87.32	55.46	0.621	0.725	1.373	1.171	0.744
1.345	37.0	69	47.08	54.93	104.04	88.71	56.34	0.633	0.739	1.400	1.193	0.758
1.350	37.4	70	47.82	55.79	105.67	90.10	57.22	0.645	0.753	1.427	1.216	0.772
1.355	37.8	71	48.57	56.66	107.31	91.51	58.11	0.658	0.768	1.455	1.240	0.788
1.360	38.2	72	49.35	57.57	109.03	92.97	59.05	0.671	0.783	1.483	1.265	0.803
1.365	38.6	73	50.13	58.48	110.75	94.44	59.98	0.684	0.798	1.513	1.289	0.818
1.370	39.0	74	50.91	59.39	112.48	95.91	60.91	0.698	0.814	1.543	1.314	0.835
1.375	39.4	75	51.69	60.30	114.20	97.38	61.85	0.711	0.829	1.573	1.339	0.850
1.380	39.8	76	52.52	61.27	116.04	98.95	62.84	0.725	0.846	1.603	1.366	0.868
1.3833	40.0	76.7	53.08	61.92	117.27	100.00	63.51	0.735	0.857	1.623	1.383	0.879
1.385	40.1	77	53.35	62.24	117.88	100.51	63.84	0.739	0.862	1.633	1.392	0.884
1.390	40.5	78	54.20	63.23	119.75	102.12	64.85	0.753	0.879	1.665	1.420	0.902
1.395	40.8	79	55.07	64.25	121.68	103.76	65.90	0.768	0.896	1.697	1.447	0.919
1.400	41.2	80	55.97	65.30	123.67	105.46	66.97	0.783	0.914	1.731	1.476	0.937
1.405	41.6	81	56.92	66.40	125.75	107.24	68.10	0.800	0.933	1.767	1.507	0.957
1.410	42.0	82	57.86	67.50	127.84	109.01	69.23	0.816	0.952	1.803	1.537	0.976
1.415	42.3	83	58.83	68.63	129.98	110.84	70.39	0.832	0.971	1.839	1.568	0.996
1.420	42.7	84	59.83	69.80	132.19	112.73	71.59	0.849	0.991	1.877	1.600	1.016
1.425	43.1	85	60.84	70.98	134.43	114.63	72.80	0.867	1.011	1.915	1.633	1.037
1.430	43.4	86	61.86	72.17	136.68	116.55	74.02	0.885	1.032	1.955	1.667	1.058
1.435	43.8	87	62.91	73.39	138.99	118.52	75.27	0.903	1.053	1.995	1.701	1.080
1.440	44.1	88	64.01	74.68	141.44	120.61	76.59	0.921	1.075	2.037	1.736	1.103
1.445	44.4	89	65.13	75.98	143.90	122.71	77.93	0.941	1.098	2.080	1.773	1.126
1.450	44.8	90	66.24	77.28	146.36	124.81	79.26	0.961	1.121	2.123	1.810	1.150
1.455	45.1	91	67.38	78.60	148.86	126.94	80.62	0.981	1.144	2.167	1.848	1.173
1.460	45.4	92	68.56	79.98	151.47	129.17	82.03	1.001	1.168	2.212	1.886	1.198
1.465	45.8	93	69.79	81.42	154.20	131.49	83.51	1.023	1.193	2.259	1.927	1.224
1.470	46.1	94	71.06	82.90	157.00	133.88	85.03	1.045	1.219	2.309	1.969	1.250
1.475	46.4	95	72.39	84.45	159.94	136.39	86.62	1.068	1.246	2.360	2.012	1.278
1.480	46.8	96	73.76	86.05	162.97	138.97	88.26	1.092	1.274	2.413	2.058	1.307
1.485	47.1	97	75.18	87.70	166.09	141.63	89.95	1.116	1.302	2.466	2.103	1.335
1.490	47.4	98	76.80	89.60	169.69	144.70	91.90	1.144	1.335	2.528	2.156	1.369
1.495	47.8	99	78.52	91.60	173.48	147.93	93.95	1.174	1.369	2.593	2.211	1.404
1.500	48.1	100	80.65	94.09	178.19	151.96	96.50	1.210	1.411	2.672	2.278	1.447
1.501	48.2	100.2	81.09	94.60	179.16	152.78	97.03	1.217	1.420	2.689	2.293	1.456
1.502	48.3	100.4	81.50	95.08	180.07	153.55	97.52	1.224	1.428	2.704	2.306	1.465
1.503	48.6	100.6	81.91	95.55	180.96	154.31	98.00	1.231	1.436	2.720	2.319	1.473
1.504	48.3	100.8	82.29	96.00	181.81	155.04	98.46	1.238	1.444	2.735	2.332	1.481
1.505	48.4	101	82.63	96.39	182.55	155.67	98.86	1.244	1.451	2.748	2.343	1.488
1.506	48.4	101.2	82.91	96.76	183.25	156.27	99.27	1.249	1.457	2.759	2.353	1.494

S. G. at 4° (va- cuum)	Reaumé Degrees	Twadell Degrees	100 weight parts contain					1 lit. contains kg				
			N ₂ O ₄	HNO ₃	acid of 36° B _é	acid of 40° B _é	acid of 48.5° B _é	N ₂ O ₄	HNO ₃	acid of 36° B _é	acid of 40° B _é	acid of 48.5° B _é
1.507	48.5	101.4	83.26	97.13	183.95	156.86	99.62	1.255	1.464	2.773	2.364	1.502
1.508	48.5	101.6	83.58	97.50	184.65	157.47	100.00	1.260	1.470	2.784	2.374	1.508
1.509	48.6	101.8	83.87	97.84	185.30	158.01	100.35	1.265	1.476	2.795	2.384	1.514
1.510	48.7	102	84.09	98.10	185.79	158.43	100.62	1.270	1.481	2.805	2.392	1.519
1.511	48.8	102.2	84.28	98.32	186.21	158.79	100.84	1.274	1.486	2.814	2.400	1.524
1.512	48.8	102.4	84.46	98.53	186.61	159.13	101.06	1.277	1.490	2.822	2.406	1.528
1.513	48.9	102.6	84.63	98.73	186.98	159.45	101.26	1.280	1.494	2.829	2.413	1.532
1.514	48.9	102.8	84.78	98.90	187.30	159.72	101.44	1.283	1.497	2.835	2.418	1.535
1.515	49.0	103	84.92	99.07	187.63	160.00	101.61	1.287	1.501	2.843	2.424	1.539
1.516	49.1	103.2	85.04	99.21	187.89	160.22	101.75	1.289	1.504	2.848	2.429	1.543
1.517	49.2	103.4	85.15	99.34	188.14	160.43	101.89	1.292	1.507	2.854	2.434	1.546
1.518	49.2	103.6	85.26	99.46	188.37	160.63	102.01	1.294	1.510	2.860	2.439	1.549
1.519	49.3	103.8	85.35	99.57	188.58	160.81	102.12	1.296	1.512	2.864	2.442	1.551
1.520	49.4	104	85.44	99.67	188.77	160.97	102.23	1.299	1.515	2.869	2.447	1.554

cost of production is such that the product shows a considerable profit when compared with the prices of Chili saltpetre as a standard. Atmospheric nitrogen may also be obtained in the form of nitrites by means of this process. See also Germ. Pat. 180691, 182297, 182849, 184958, 185094, 186454 and French Pat. 374237.

Other methods of obtaining nitric acid in a novel manner may be omitted here as they have no practical value.

Pure HNO₃ is a clear, fuming, strongly corrosive liquid with a strong smell. Originally as clear as water it becomes yellow by the action of light. The monohydrate boils at 86°; with partial decomposition into N₂O₄ and O so that the boiling point rises to 126° where it remains constant. The distillate is 2 HNO₃ + 3 H₂O.

The red fuming nitric acid has a S. G. above 1.4 (usually 1.5); its density differs from that of the colourless HNO₃ in quite an unaccountable way. According to LUNGE and MARCHLEWSKI the following corrections for S. G. should be observed for HNO₃ containing N₂O₄ in the case of acids of specific gravity 1.496 (at 15°/4°); the figures following the percentage of N₂O₄ given in the following table should be subtracted in order to find the S. G. of the HNO₃ actually present.

N ₂ O ₄ %	Increase of S. G. due to N ₂ O ₄	N ₂ O ₄ %	Increase of S. G. due to N ₂ O ₄	N ₂ O ₄ %	Increase of S. G. due to N ₂ O ₄	N ₂ O ₄ %	Increase of S. G. due to N ₂ O ₄	N ₂ O ₄ %	Increase of S. G. due to N ₂ O ₄
0.25	0.00050	3.00	0.01800	5.50	0.03600	8.00	0.05325	10.50	0.06975
0.50	0.00075	3.25	0.01985	5.75	0.03775	8.25	0.05500	10.75	0.07135
0.75	0.00150	3.50	0.02165	6.00	0.03950	8.50	0.05660	11.00	0.07300
1.00	0.00300	3.75	0.02350	6.25	0.04175	8.75	0.05825	11.25	0.07450
1.25	0.00475	4.00	0.02525	6.50	0.04300	9.00	0.06000	11.50	0.07600
1.50	0.00675	4.25	0.02690	6.75	0.04475	9.25	0.06160	11.75	0.07750
1.75	0.00775	4.50	0.02875	7.00	0.04650	9.50	0.06325	12.00	0.07850
2.00	0.01050	4.75	0.03050	7.25	0.04720	9.75	0.06500	12.25	0.08050
2.25	0.01250	5.00	0.03225	7.50	0.05000	10.00	0.06600	12.50	0.08200
2.50	0.01425	5.25	0.03365	7.75	0.05165	10.25	0.06815	12.75	0.08350
2.75	0.01625								

HNO₃ is used in making H₂SO₄, for colouring copper alloys (yellow) for nitration, preparation of tar colours and explosives and many other technical purposes.

Nitric acid Plants of Earthenware:

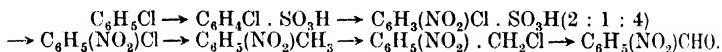
Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Earthenware-condensing vessels for nitric acid:

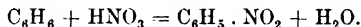
Fr. Chr. Fikentscher, Zwickau Sa., Germany (see front part advt.).

Nitrites see under the respective metals.

Nitrobenzaldehyde. $C_6H_5(NO_2).CHO$. o-nitrobenzaldehyde is of importance in the synthesis of indigo. It may be produced by the oxidation of o-nitrocinnamic acid with $KMnO_4$. It is usually prepared, by a patented method, from o-nitrobenzylchloride $C_6H_5(NO_2).CH_2Cl$, by converting this into the sulphonic acid, separating nitrobenzylalcohol $C_6H_5(OH).CH_2.OH$ and oxidizing the latter to nitrobenzaldehyde. o-nitrobenzylchloride is obtained from o-nitrotoluene by chlorinating the side chain. For further details see "INDIGO COLOURS". The French Pat. 330524 for producing o-nitrobenzaldehyde from monochlorobenzene is certain to have no practical importance. It is as follows:—



Nitrobenzene. $C_6H_5.NO_2$. Obtained by nitrating benzene, according to the equation:



The nitration is done by nitrating acid (see "NITRATION"); 100 kg benzene, 120 kg HNO_3 of 42° Bé and 180 kg H_2SO_4 of 66° Bé are taken. The reaction is carried out in iron or earthenware vessels, surrounded by a jacket cooled with water. The mixing of benzene and nitrating acid is done by stirrers and a thermometer is also provided. While the first $\frac{3}{4}$ of the nitrating acid is added to the benzene the temperature must not rise above 25° C; steam is then allowed to enter the jacket, until a temperature of + 70° C is reached in the nitrating vessel. The addition of the acid for the nitration of 100 kg benzene takes about 10 hours; after that the stirrers continue to work for another 6 hours. Finally the mixture is run into another vessel from which it is forced into an elevated reservoir, conical below. The nitrobenzene collects at the top and the waste acid at the bottom. The latter is tapped off from below, the nitrobenzene is freed from adhering acid particles by repeated washing and finally distilled in a current of steam. Further refining removes unchanged benzene. The purity of the product depends upon that of the benzene used. Commercially a distinction is drawn between light nitrobenzene (almost pure) and heavy nitrobenzene (a mixture of nitrobenzene with the higher homologues). The B. P. of the latter is between 200° and 240° C. S. G. (at 15° C) is about 1.18.

Pure nitrobenzene is a colourless strongly refracting liquid with a smell of bitter almonds; it is poisonous, insoluble in H_2O , and solidifies to a crystalline mass on cooling; it mixes in any proportion with alcohol, ether and benzene. S. G. (at 15° C) 1.209; M. P. + 3°; B. P. 205°.

It is the most important crude material in the manufacture of aniline (q. v.), of quinoline, benzidine, azobenzene, &c. In perfumery it is used as a substitute for oil of bitter almonds. It is also of importance for explosive purposes.

TEST. In testing the commercial article the B. P. is of great importance; nitrobenzene used for the manufacture of blue oils should distil almost

completely within one degree, while for other purposes variations between 204.5—208° are allowable. Of the quantitative composition and the B. P. of heavy nitrobenzenes nothing definite can be said.

Nitrobenzene Rectifying apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 8b (see advts.).

Nitrobenzoic acids see "BENZOIC ACID".

Nitrocellulose. When cellulose is nitrated (see "NITRATING") either dinitrocellulose (collodion wool) or trinitrocellulose is formed, the product depending upon the strength. The latter is sometimes regarded as hexanitrocellulose and known as GUN COTTON.

For details see the articles on "CELLULOSE", "COLLODION", "GUN COTTON", and "SILK, ARTIFICIAL". In the last named article, and under "NITRATION", methods for rendering nitrocellulose non-inflammable and incombustible are discussed.

Nitro compounds see "NITRATION", "NITRANILINE", "NITROBENZALDEHYDE", "NITROBENZENE", "DINITROBENZENE", "NITROPHENOLS", "NITROTOLUENE", "DINITROTOLUENE", "TRINITROTOLUENE", "NITROGLYCERINE", "NITRONAPHTHALENE", "COLLODION", "GUN COTTON", "PICRIC ACID", "PROPIOLIC ACID".

Nitro dyestuffs. A class of dyestuffs containing the nitro group, NO_2 , as chromophore; more than one NO_2 group is often present. The hydroxyl group OH, and sometimes the imido group NH are frequently present as salt forming radicals. All colours of this group have an acid character and give yellow shades. It should be remarked that all nitroderivates of amines and phenols (especially of the latter) exhibit more or less marked dyeing properties. The oldest known nitro-colour — and at the same time the oldest known tar-colour — is picric acid (q. v.). Besides this should be mentioned MARTIUS yellow (naphthol yellow, Manchester yellow), (Na -, NH_4 - or Ca -salt of dinitro α -naphthol ($\text{OH} : \text{NO}_2 : \text{NO}_2 = 1 : 2 : 4$) originally obtained from α -naphthylamine by diazotizing and then treating with HNO_3 . Later it was shewn to be formed from α -naphthol sulphonic acid and nitric acid; Now α -naphthol is dissolved in concentrated H_2SO_4 and nitrated by warming the solution with HNO_3 to 100° C. It is then diluted and converted into the sodium salt. The crystallized alkali salts of dinitro- α -naphthol are yellow to orange in colour and dissolve more or less readily in water. Alkali salt of the β -sulphonic acid of MARTIUS yellow is on the market under the name NAPHTHOL YELLOW (ACID YELLOW S).

Nitrogen. N. Atomic weight = 14.04. Colourless gas, odourless and tasteless. S. G. (air = 1) 0.9713; S. G. ($\text{H} = 1$) 13.98. Critical temperature — 146° C; critical pressure 3.5 atm.; B. P. of liquid nitrogen under 760 mm mercury — 194.4° C; S. G. at this temperature ($\text{H}_2\text{O} = 1$) is 0.885. By reducing the pressure to 60 mm mercury, liquid nitrogen may be cooled to — 214° when it becomes solid.

Nitrogen, a very inert element is usually obtained from the air, which is freed from CO_2 by KOH and from water vapour by H_2SO_4 . Finally the oxygen is removed by alkaline pyrogallous acid solution or by conducting it over red hot copper turnings. According to the Germ. Pat. 134134 oxygen and nitrogen are obtained from the air by means of potassium manganate; by conducting air and steam alternately over the manganate, the O of air is absorbed so

that N alone remains. We cannot discuss the details of this method, which, does not appear very promising.

N is obtained pure from ammonium nitrite $\text{NH}_4 \cdot \text{NO}_2$; the dry salt is either heated, or a concentrated aqueous solution of potassium nitrite is heated with sal ammoniac; in the latter case it is well to add a little potassium bichromate. According to v. KNORRE it is better to heat a solution of one part potassium nitrite, 1—2 parts ammonium sulphate, and 1 part neutral potassium chromate; the nitrogen developed is washed by dilute H_2SO_4 or better still by a mixture of $\text{K}_2\text{Cr}_2\text{O}_7$ and H_2SO_4 .

KNIETSCH (paper read at the V. Intern. Congr. for Applied Chem., Berlin, 1903) recommends the following method of preparing pure nitrogen: A mixture of air and hydrogen is conducted over platinized asbestos; when the O is separated as H_2O and then over heated CuO , when the excess of H is also removed as H_2O .

It is dangerous to prepare N by passing Cl into aqueous ammonia, as with excess of Cl, nitrogen chloride, a violent explosive, is formed.

For PICTER's method of separating atmospheric air into nitrogen and oxygen by thermo-mechanical means, see "OXYGEN".

The methods for making use of atmospheric nitrogen are mentioned in the articles on "AMMONIA", "CALCIUM CYANAMIDE" under "CALCIUM COMPOUNDS", "NITRIC ACID".

Nitrogen compounds. The most important industrially are ammonia and nitric acid; both are treated in special articles. Nitrates and nitrites see under the respective metallic compounds. ETHYL NITRITE under "ETHYL COMPOUNDS". See also "NITROGLYCERINE", "COLLODION", "PICRIC ACID", &c.

Nitroglycerine. (NOBEL's explosive oil; trinitroglycerine, trinitrine). $\text{C}_3\text{H}_5(\text{O} \cdot \text{NO}_2)_3$. It is obtained by nitrating glycerine with nitrating acid (nitrosulphonic acid). The glycerine should be of at least 30° Bé (i. e. S. G. 1.2505) and as pure as possible. The HNO_3 should have a S. G. 1.485—1.500 and not contain more than 1 % nitrous acid. The H_2SO_4 must be as pure as possible and of S. G. 1.845. For 100 kg glycerine an acid mixture of 450 kg H_2SO_4 and 250 kg HNO_3 is used; it is mixed in stirring vessels, passed through a cooling box into a vessel from which it is forced by compressed air into nitrating vessels. These consist of a lead vessel surrounded by a wooden cooling vat containing cooling coils. During the process of nitration H_2O is allowed to run through the coils as well as through the space between the lead and wooden vessels. The glycerine under pressure drops into the cooled acid mixture passing through to the bottom of the nitrating vessel. It is important that the glycerine should be continuously and thoroughly mixed with the acids; this is best effected by blowing in dry air by injectors. During nitration which lasts about one hour, the temperature in the nitrating vessel must not rise above 30° C.

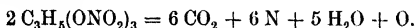
Formerly the nitroglycerine formed was separated from the acids by allowing water to run through. As by this method the acids are wasted the whole substance is now placed in lead vessels the sides of which converge towards the bottom; the acids collect at the bottom and can be run off. After this it is stirred repeatedly with water by means of injected compressed air. Finally it is washed with soda solution until the acid reaction disappears, when it is filtered through felt to remove the slimy and muddy impurities. By putting a layer of common salt on the felt the water held in emulsion by the glycerine, is held back. The nitrous gases leaving the nitrating vessel are conducted to an absorption tower.

According to Amer. Pat. 841886 nitroglycerine can be obtained by the action of a mixture of Nordhausen sulphuric acid and fuming HNO_3 . In this process the proportion of HNO_3 to H_2SO_4 is much greater than usual.

According to Germ. Pat. 183183 glycerine is drawn through the nitrating acid in the form of a spray.

Germ. Pat. 181489 has for its object the quicker separation of the glycerine. This is attained by the addition of some substance (preferably an alkali fluoride) to the acids and to the glycerine, so that any emulsion or colloidal matter that may be formed is redissolved.

From 100 kg glycerine 200–205 kg pure nitroglycerine (theoretically 246.74 kg) are obtained. It is a colourless or very slightly yellow oil, odourless, of sweetish taste, very poisonous. S. G. 1.6; it is not easily soluble in H_2O though very readily in alcohol and ether. At -15°C nitroglycerine becomes viscous without solidifying, while at temperatures between $+8^\circ$ and -11° it crystallizes in long needles. It explodes by pressure or detonation (for instance by mercury fulminate) and also on heating to 250°C . On explosion it decomposes as follows:



1 litre nitroglycerine yields 1298 litres of gas, which expand to 10 400 litres at the moment of explosion (GUTTMANN). Frozen nitroglycerine explodes less readily than liquid; impure products are usually very dangerous. It is used to make dynamites (q. v.), smokeless powder (see "GUN POWDER"), and occasionally it is used medicinally.

French Pat. 341911 and Engl. Pat. 8041 of 1904 are remarkable in attempting to produce dinitroglycerine and dinitroglycerine explosives. GUTTMANN writes as follows (Chem. Zeitschr. IV, 175). Dinitroglycerine is said to be much more stable than trinitroglycerine, less sensitive to mechanical effects and heat and no explosion is said to have occurred by ignition. Mixed with trinitroglycerine it is said to render the latter less dangerous. Its preparation is said to be without danger, and decomposition of even considerable quantities causes no explosion. It practically never freezes, and when added to trinitroglycerine depresses the freezing point of the latter, e. g. a mixture of 60 % dinitroglycerine and 40 % trinitroglycerine does not freeze. As dinitroglycerine does not contain sufficient oxygen to combine with the carbon, and trinitroglycerine contains too much, a proper mixture of the two should produce a product which is stronger than trinitroglycerine. Powder made with dinitroglycerine evolves less heat and the gases are developed more slowly. Dinitroglycerine not only dissolves readily in trinitroglycerine, but a mixture in any proportions may be made. Dinitroglycerine gelatinizes as easily as trinitroglycerine. Dinitroglycerine is produced by cooling and mixing 10 parts by weight glycerine of S. G. 1.262 with 33 parts HNO_3 of S. G. 1.50. The HNO_3 is allowed to run slowly into the glycerine, stirring all the while. If necessary this is allowed to stand for several hours at 10°C until the mononitroglycerine at first formed is converted into dinitroglycerine. The mixture is then diluted with 10 parts cold water and the HNO_3 neutralized by suitable means, for instance with CaCO_3 , until the solution has a density of 1.58. The dinitroglycerine rises to the top and can easily be taken up, purified and dried. The residue of dinitroglycerine in the lye is extracted with ether. The dinitroglycerine obtained is easily soluble in H_2O and can therefore be obtained perfectly pure by evaporation or fractional distillation. Its N-contents are theoretically 15.38 %, and analysis demonstrates on an average 15.35 %. By a suitable mixture of HNO_3 and H_2SO_4 any proportions of di- and trinitroglycerine may be obtained. The concentration and relative amounts of the acids, the temperature and time of nitrating have an important influence. — Dinitroglycerine alone is probably not capable of use as an explosive

as it contains too little oxygen (2 atoms) for complete combustion. On the other hand it should find employment in explosives as well as powders in consequence of its property of depressing the freezing point of trinitroglycerine and its influence on the ignition point. In the former case the necessary O could be produced by suitable additions; as, however, dinitroglycerine is not only soluble in H_2O but is also said to be hygroscopic difficulties both for its use in explosives and in powders will probably have to be faced.

Nitroglycerine:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin W. 9.

Nitronaphthalenes. $C_{10}H_7.NO_2$. The only one of importance is α -mononitronaphthalene; it is produced from naphthalene by nitration, the process being similar to that used in the manufacture of nitrobenzene. 10 parts naphthalene, 8 parts HNO_3 (S. G. 1.4) and 10 parts H_2SO_4 (S. G. 1.84) are used. The temperature of the mixture is gradually raised to $70^\circ C$ and kept there for 6 hours after the last naphthalene has been added. At the same temperature also the fused α -nitronaphthalene is separated from the waste acid, washed several times with boiling H_2O and then run into cold H_2O with continual stirring where it solidifies in a granular form. It forms bright yellow crystals, insoluble in H_2O , readily soluble in benzene, carbon disulphide and hot alcohol. M. P. 61° . It is used in the preparation of α -naphthylamine (q. v.) and to remove the phosphorescence from oil.

Nitrophenols. Since benzene became cheap it has been largely used for making nitrophenols. It is converted into chlorbenzene and the latter is nitrated. By systematic fractionation *in vacuo* (patented method) the products of nitration, o- and p-nitrochlorobenzene are separated from each other. From these derivatives the widely used o- and p-nitrophenols are easily obtained.

Nitroso dyestuffs (Quinonoxime dyestuffs). A class of synthetic coal-tar colours, obtained by the action of nitrous acid on phenols.

They contain the group $\begin{array}{c} \text{— O —} \\ \diagup \quad \diagdown \\ \text{— N — OH} \end{array}$ which is to be regarded as derived by

substituting an oxygen atom in a quinone by the oximido group. The dyestuffs are the result of the action of nitrous acid on phenols and are chiefly used to produce green colour on metallic mordants. So for instance solid green (dinitroso-resorcline), obtained by the action of nitrous acid on resorcline, is used to dye wool dark green on an iron mordant.

Nitro starch. According to the Amer. Pat. 779421 a stable nitrated starch is obtained if the nitro starch after nitration is separated from the acids and boiled with H_2O and $CaCO_3$. A second patent (Amer. Pat. 779422) recommends dissolving the nitrated starch in a mixture of alcohol and acetone; the acetone is then evaporated off and the nitro starch freed from alcohol.

Nitrotoluenes. $C_6H_4(NO_2).CH_3$. Of the three isomers only o- and p-nitrotoluene are used; they are both obtained by the nitration of toluene, in varying proportions depending on the kind of acid used for nitration. The preparation is similar to that of nitrobenzene (q. v.); strong cooling at the out-set is essential. In order to separate the isomers the mixture of both is distilled under reduced pressure using a column apparatus over a free flame. If 40 % of the purified nitrotoluene mixture used is driven off the distillate consists of practically pure o-nitrotoluene, while from the remainder on cooling almost pure p-nitro-

toluene separates. The latter is freed from the mother liquor by suction and pressure.

According to Germ. Pat. 158219 commercial o-nitrotoluene is freed from the p- and m-compounds by allowing the crude product to crystallize partially at a temperature between -4° and -10° . The crystals obtained consist of pure o-nitrotoluene; they are separated from the still liquor impurities by means of a centrifuge placed in a room cooled to -4° C.

Commercial nitrotoluene (also known as very heavy nitrobenzene) contains more o- than p-nitrotoluene; it is said to have a S. G. of 1.167 and to distil between 220 and 240° C.

Pure o-nitrotoluene is a yellowish liquid. S. G. (at 23.5°) 1.162; B. P. 223° . The determination of the B. P. is a test of its purity.

Pure p-nitrotoluene forms colourless crystals (prisms); M. P. 54° ; B. P. 236° . The determination of the M. P. is a test of its purity.

m-nitrotoluene, hardly used at all commercially, is obtained from m-nitro-p-toluidine. The o- and p-compound are used in the preparation of toluidine, tolidine, fuchsine, &c.

See also the articles on "DINITROTOLUENE" and "TRINITROTOLUENE".

Nitrotoluene:

Sprenstoff A.-G. Carbonit, Hamburg.

Nizolysol. A new lysol preparation with a more agreeable smell than the usual lysol (q. v.).

Non-alcoholic beverages. The growing temperance movement has led to the introduction of numerous non-alcoholic beverages, i. e. of liquids which as far as appearance, taste and character go resemble alcoholic refreshments such as wine, beer, liqueurs, &c. except that they contain no alcohol.

It has frequently happened that when these liquids were analyzed it was found that they were not quite free from alcohol, and as chemists were then in doubt as to the verdict that should be given, the Union of Swiss Analytical Chemists has established the following "CHARACTERIZATION OF NON-ALCOHOLIC BEVERAGES".

"A beverage is to be regarded as practically free from alcohol if the specific gravity of the distillate is more than 0.9992. The test is conducted like the determination of alcohol in wine. When sufficient material is available in order to make the examination more definite the distillation is carried out as follows:— exactly 50 ccm are distilled from 250 ccm of the beverage and the specific gravity of the distillate determined. In this case the lowest limit is to be 0.9963."

Including effervescent lemonades there are four groups of non-alcoholic beverages, viz: 1. Non-alcoholic wines, 2. non-alcoholic beers, 3. effervescent lemonades, and 4. non-alcoholic milk beverages.

Non-alcoholic beverages are produced by various methods. Apple juice, grape juice, &c. is pasteurised in bottles (see "MILK"), more rarely by sterilization at a high temperature. Frequently sugar is added, and the substance thickened by boiling.

Others are mixtures of sugar-syrup and essential oils. Special essences soluble in water are now sold, which are mixed with the requisite amount of sugar syrup to give "non-alcoholic liqueurs", "non-alcoholic punch essences", &c., i. e. beverages resembling in flavour those of an alcoholic nature. The following are a number of special methods:

According to Germ. Pat. 130103 for the preparation of clear non-alcoholic fruit juices, the fruit is pressed out in the usual way or extracted with water. The juice obtained is then treated as follows: About 50—100 g apple extract are dissolved in 1 litre water. According to the acid contained, quantities

up to 1 % of tartaric acid are added to the solution and the mixture placed in a boiling vessel and heated under pressure at 100—120° for several hours, until a small amount taken out becomes clear on cooling and can then be filtered.

Germ. Pat. 130625 protects the preparation of non-alcoholic aerated beverages by fermentation due to the ferment *Leuconostoc dissiliens* which splits fermentable sugar solutions into CO₂ and dextrose without producing alcohol. Quite similar to this is the method of Germ. Pat. 149342. The fruit juice is fermented by a species of the genus *Sachsisia* (ether alone or in conjunction with lactic acid bacteria). After fermentation the liquid, which resembles hock, is sterilized and filtered.

According to Germ. Pat. 151123 malt or fruit extract is treated with pure cultures of lactic acid bacteria at 45—50°, until about 1 % acid is present. After sterilization, the liquid is neutralized with Na₂CO₃ until only 0.2 % acid remains, clarified, sterilized again and aerated by forcing in CO₂.

According to LAPP's method (Amer. Pat. 786771) the juice is mixed with yeast, the mixture kept, in the absence of air, at a temperature of 0° until it becomes cloudy. The yeast is then removed, the residue filtered and saturated with CO₂. Germ. Pat. 160497 protects the preparation of a nonalcoholic beverage resembling beer. Ordinary beer is distilled in a current of air and steam and the alcohol is driven off.

The Germ. Pat. 160496 starts from fermented malt; it is fermented in such a way as to produce only a small amount of alcohol. The fermented malt is separated from the yeast, treated with hops and boiled to remove alcohol. From the result of other experiments on these lines the method does not seem feasible, since during the process, flavouring matters are either removed or altered in character.

For an apparatus used to remove alcohol from beer, &c., see Germ. Pat. 176198.

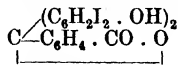
According to Germ. Pat. 167491 an alcohol-free "beer" may be obtained in the following way. Finely shredded malt and hops are mashed in hot (not boiling) water and kept at the same temperature for 1 hour with constant stirring. The mash is then boiled for ½ hour, cooled, treated with a small quantity of malt dust, the hops and "grains" removed by filtration, treated with CO₂ after cooling to 15°, transferred to a large vat where it is further cooled, bottled and sterilized in a steam oven.

The preparation of an alcohol-free beverage with a taste like beer is protected by Germ. Pat. 180288. The taste of wort is removed by keeping the yeast beforehand at a temperature between 6° and the optimum temperature for its growth. After treatment with this yeast the wort is allowed to remain for some time at 0°.

According to Dan. Pat. 7555 (1904) the wort and CO₂ fall into a vessel in the form of a fine spray. The method seems open to question.

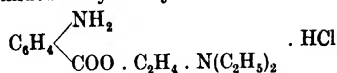
Nordhausen sulphuric acid see "SULPHURIC ACID, FUMING".

Nosophene (Jodophene) = Tetrajodophenolphthalein.



Obtained by the action of I in KI on an alkaline solution of phenolphthalein. It is a brown-yellow odourless and tasteless powder, insoluble in H₂O and acids. It is used (and also its salts) for medical purposes, internally as an intestinal astringent, externally as a substitute for iodoform. — Sodium nosophene, see "ANTINOSINE", bismuth nosophene, see "EUDOXINE".

Novocaine = p-amidobenzoyldiethylamidoethanol



Small crystalline needles M. P. 156° , soluble in H_2O in the proportion 1 : 1. The aqueous solution may be boiled without decomposition.

An excellent local anaesthetic, a very good substitute for cocaine; it is used and applied like the latter. For many purposes solutions of novocaine and suprenine are very suitable.

Novorenal. A solution of novocaine and adrenaline, sold as an anaesthetic in sealed tubes in various strengths.

Novozone. A registered name (in Germany) for magnesium peroxide prepared for medical purposes according to the method of Dr. HINZ. It is used internally and externally as an ointment for wounds and gatherings. Its use is based upon its strong oxidizing action.

Nucleic acids. Organic acids of unknown constitution. They contain N and P and are nearly always found as constituents of cell nuclei. BOEHMEYER'S nucleic acid is obtained from yeast. Sodium nucleate is recommended for use in abdominal surgery. It increases *leucocytosis* and so lessens the risk of infection.

Nuremberg violet see "MANGANESE COLOURS".

Nut oil (*Oleum juglandis*, WALNUT OIL). Obtained by pressing walnuts as a greenish oil turning yellow on standing. It is tasteless and has only a faint smell. S. G. at 15° . It is a "quick drying oil" and easily becomes rancid. It is viscid at -15° , beginning to melt at -27° . Saponification number 196; iodine number 142—144. The best qualities are used for domestic purposes (as a flavouring) while the oil obtained by extraction with hot water from the residue left after preparing the best oils is used as a substitute for linseed oil. It is used in making varnishes and soap.

Nutrose. Sodium compound of caseine. It is prepared according to Germ. Pat. 85057. The caseine of fresh cow's milk is precipitated and converted into nutrose by treatment with NaOH or Na_2CO_3 .

Nutrose is a white, almost odourless and tasteless powder, sparingly soluble in cold, readily in hot H_2O ; it is considered an excellent nourishing food; it contains 65.2 % albuminous substance, 20.15 % nitrogen-free matter, 4.15 % mineral matter, and 10.5 % water.

O

Oils. See also "FATS AND OILS", "MINERAL OILS", "PETROLEUM", "LUBRICANTS" and "OILS, ESSENTIAL".

It should be noticed that recently water-soluble oils have become of more and more use. They all emulsify readily with water in consequence of the alkali soap which they contain. In this form they are used to grease tool machines, to oil wool for spinning and as ointments, &c. According to BOLEG (Germ. Pat. 129480) mineral oils (heavy tar oils) are made soluble in water by adding crude resin oils, saponifying the resin acids in the latter by alkalies and subsequently oxidizing under pressure. After this treatment they can

retain considerable quantities of water and remain clear. See also Germ. Pat. 122451 and 148168.

Oil-testing apparatus:

Sommer & Runge, Berlin-Friedenau, Bennisen-Str. 23/24.

Oil-extracting Plant:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advts.).

Oil Presses:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Oils spinning (Melting mediums) are used for making woolfibres slippery while spinning. See "Isol".

Spinning oil (watersoluble):

Louis Blumer, Zwickau Sa., Germany.

Dr. Roth's Inertol:

Paul Lechler, Stuttgart, Germany.

Oil black see "LAMPBLACK" (Soot).

Oil blue see "IRON COLOURS" and "COPPER COLOURS".

Oil cakes see "FEEDING STUFFS".

Oil colours. These are colours which are worked up with drying oils or with oil varnishes. They are used for weather proof painting for buildings, &c. and the more choice kinds for art purposes, painting in oils, &c. Formerly the artist or workman himself mixed the pulverized colour with oil varnish in a pestle and mortar, but now oil paints are usually sold ready made, the oil and colouring matters being mixed to about the thickness of butter. The colours can now also be bought so finely ground, pulverized and moistened that they can be very readily mixed with the oil varnish. The amount of oil necessary for mixing the colour depends on the nature of the pigment itself and varies greatly. The less oil the colour requires the more quickly it dries.

Oil colours:

Dr. Fr. Schoenfeld & Co., Düsseldorf, Germany.

Oil gas. The raw materials from which this substance is made are a fraction of petroleum, not suitable for illuminating purposes, and yet not fit to serve as a lubricant, heavy oils from brown coal-tar and paraffin distillation and finally certain vegetable oils, such as rape oil, used as lubricants for railway carriages, &c.

For methods, &c. compare COAL GAS. The retorts employed for making oil gas must be so constructed that the oil which is slowly introduced, first evaporates, and is only converted into gas when more heat is applied. The products must, at the same time, not be subjected to further increase of temperature. The crude gas which leaves the retort is treated in much the same way as coal gas. It passes through a tar receiver, and through cooling, washing and purifying apparatus, and is finally collected in a suitable gasometer.

Owing to the high percentage of heavy hydrocarbons oil gas is as an illuminant three or four times as strong as coal gas. It is therefore burnt in very small burners with much air. When compressed it is used for lighting railway carriages. It is also used for carburetting coal gas and water gas, and in some cases for driving gas engines.

According to Engl. Pat. 10527 (1903) an oil gas with good burning properties is obtained by mixing hydrogen or compounds rich in hydrogen with the oil vapour before converting into gas. The diluting agent is separated as far as possible from the hydrocarbons by fractional distillation, and can be returned to the retorts. It is said that this method lessens the formation of tar and coke during the production of gas. A liquid for illuminating purposes called BLAU GAS after the inventor BLAU, is produced from oil gas, by washing under high pressure with a suitable absorbent, thus separating the so-called permanent gases from those which can be condensed. This illuminating gas, thus separated at a normal temperature from the gases which cannot be rendered fluid, is kept under pressure in steel cylinders. Blau gas has a S. G. of 0.51, is said to be less explosive than acetylene and less poisonous to breathe than coal gas. See Germ. Pat. 158198 and 175846.

Oil green see "CHROME COLOURS".

Oil mordants. These are only used in the process of dyeing TURKEY-RED on cotton (q. v.). Formerly the bleached cotton fabric was steeped in an emulsion of tournant oil with K_2CO_3 5—6 times, at intervals of a week. After each treatment the material was wrung out and allowed to dry in the open air. This long and troublesome process (white mordant process), has now been superseded, and is very rarely used. The modern method is to use the so-called Turkey-red oils, that is the aqueous solutions of oil mordants, obtained by treating olive oil or castor oil with concentrated H_2SO_4 . The Turkey-red oils are made from olive oil by treating oil with half its weight of concentrated H_2SO_4 in an vessel which is kept cool. After standing for 12 hours twice the weight of water and $\frac{1}{5}$ the weight of soda lye, 36 Bé, is added, the mixture well stirred and allowed to settle. Finally the aqueous layer is drawn off and the oily part neutralized with soda lye or ammonia. The mordant thus obtained mixes with H_2O to give a homogeneous slightly turbid liquid.

Turkey-red oil, however, is more frequently made from castor oil than from olive oil. The castor oil is treated with only $\frac{1}{4}$ its weight of concentrated H_2SO_4 . It is then well mixed, avoiding carefully any rise of temperature, and after 24 hours the product is washed with common salt solution to remove the excess of H_2SO_4 . The oil mordant obtained which is soluble in water, is used as it is, or first neutralized to faint alkaline reaction.

The chemistry of the Turkey-red oil manufacture is not yet definitely known but it is apparently a question of the formation of oxy-fatty acids and their esters. It must also be mentioned that the oil mordants are not used directly for fixing cotton dyes, but are mixed with other mordants such as aluminium oxide. A bright and as a rule very fast dye is thus obtained as a result of the action between the cotton fibres, the oxy-fatty acids, the metallic oxides and the colouring matter proper.

Oils, essential. Under this name very many plant products are included. The properties common to all are:—a powerful odour, and volatility in steam without decomposition. They are also volatile at the ordinary temperatures and cause oil spots on paper which gradually disappear.

There are three methods for the preparation of essential oils: 1. Distillation with steam. 2. Extraction. 3. Pressing.

1. As already remarked, the essential oils are volatile in steam at a temperature far below their boiling point. The parts of the plants containing the oil are therefore either boiled in water, or they are exposed to the action of steam. The steam is condensed and the essential oil collects on the surface of the water in the receiver. The better plan is to distil with steam, as this prevents the delicacy of the perfume from being affected by contact with hot

H₂O, and also because in this way the other constituents of the plants are not extracted. This latter consideration greatly enhances the value of the oils.

The FLORENCE FLASK is the most suitable form of receiver. The cooling arrangements must be very carefully constructed, that the whole of the oil is condensed. In cases where stearoptenes pass over with the oil and solidify in any quantity, sufficient warm water must be used in the cooler to prevent the pipe from becoming choked. The water in the distillate sometimes contains in solution large quantities of essential oils. It is therefore treated with common salt, which decreases its solvent power and raises the boiling point; the oil is then separated off by fractionation. Sometimes essential oils are distilled without steam in a partial vacuum. In whatever way the oil is to be distilled the plants must be chopped into fine pieces, in order that the steam may freely enter the pores.

2. The extraction of essential oils by suitable solvents such as ether, acetone, carbon disulphide, methyl chloride, and others. This method is more frequently used than formerly, but can only be employed in cases where the plant contains but little fatty oils and resinous matter. These substances retain the essential oils very firmly, and distillation is necessary to separate them. For maceration and enfleurage, compare "PERFUMERY".

3. The method of obtaining essential oils by pressure is only carried out in rare cases, where the fresh plant tissues contain much oil in relatively large cells. Spindle presses are in such cases generally used; less frequently hydraulic presses are employed. A special method of pressing, the so-called needle process is alluded to in the article on ORANGE PEEL OIL.

Special methods for obtaining oils are mentioned when necessary in the articles dealing with the various essential oils. Compare also "PERFUMERY". The crude oils are purified either by being allowed to settle, by filtration, or in some cases by redistillation. This latter treatment is carried out either in a vacuum or by steam.

The preparation of essential oils free from terpenes has become of great importance, since it has been proved that in most oils the terpenes are only neutral, or even form an objectionable and unnecessary constituent, the oxygenated constituents alone bearing the valuable quality sought. According to G. HAENSEL, the essential oils are subjected to fractional distillation to free them from terpenes. As is known the true terpenes, C₁₀H₁₆, have a relatively low boiling point, 160—190°, while the oxygenated components boil at a much higher temperature. Although the details of the method for obtaining essential oils free from terpenes, are not yet published, and although in special cases considerable modifications are no doubt necessary, it is quite certain that carefully conducted fractional distillation is still the essential feature of the process. Germ. Pat. 146976 describes a new and special process for obtaining essential oils from which emulsions can be easily made, which retain all their qualities, and are soluble in water. The oils are treated with compressed air in an apparatus connected with a condenser. The temperature of the air is gradually raised from 50 to 70° in the course of half an hour. During this time 2—5 % of soda lye of 20° Bé and 2 % of hot water are added. After this preparatory process, the volatile oils are intimately mixed by compressed air for 10 minutes, at a temperature of 50—70°, with a mixture of mineral and resinous oils which must be soluble in water. They are then heated with steam for 1 hour under a pressure of ½—1 atm.

Essential Oils:

Domeier & Co. Ltd., 8 Harp Lane, London E.C.

Apparatus for essential Oils:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Oil varnishes see "LINSEED OIL VARNISHES".

Oleic acids. $C_{18}H_{34}O_2$. Commercially known as oleine. This name should, however, be applied only to the triglycerides of oleic acid. Oleic acid is obtained on a large scale as a by-product in the manufacture of stearin. When fats are saponified (compare "STEARINE", "FATTY ACIDS" and "SOAP") with sulphuric acid, the fatty acids removed by distillation are known as distilled oleine. Saponified oleine is obtained when the process is carried out in autoclaves with superheated steam. (That obtained by saponification with lime is also included under this heading.)

The mixture of fatty acids however obtained is separated by pressure into the liquid oleic acid and the solid stearine. When fatty acids are prepared by acid saponification and distillation the separation into oleine and stearine is usually accomplished by fractional distillation under reduced pressure. The liquid and solid constituents may also be separated by saponifying with superheated steam and fractionally condensing the distillate.

Oleic acid is used in the manufacture of soap. That prepared by saponification is preferred to that obtained by distillation on account of the bad soap making properties and unpleasant odour of the latter. It is also used for oiling wool in cloth manufacture.

The purest oleic acid is obtained by the saponification of linseed oil. This kind is called **LINOLEIC ACID**. For processes of converting oleic acids into solid fatty acids see **FATTY ACIDS**.

Pure oleic acid is a colourless, viscid substance. S. G. (at 14°) 0.898. It begins to soften at $+4^\circ$. M. P. $+14^\circ$. It may be distilled without decomposition in superheated steam at 250° but undergoes decomposition when distilled under the ordinary pressure. In the air it quickly becomes rancid and acquires an unpleasant smell, a rasping taste and an acid reaction.

Olive oil. Obtained from the fruit of *Olea Europaea* by pressure. The best fruits after removal of the stone give the finest table oil by slight pressing at the ordinary temperature. After this the pressure is increased and the temperature raised. In this way oils for burning and inferior kinds are obtained. The residue is finally ground and extracted (usually) with carbon bisulphide. Formerly the extraction was carried out with hot water and repeated pressing.

Another variety of oil is obtained by pressing or extracting the residue from the first pressing.

Fine qualities have a yellow to pale yellow colour; sometimes they are coloured green by chlorophyll. It has a mild pleasant taste and a peculiar faint odour. S. G. (at 15°) 0.913—0.915; iodine number 78—85; saponification number 191—194. It is a non-drying oil which rapidly becomes rancid.

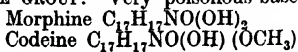
The best qualities are used as salad oil and are frequently adulterated. The other kinds are used for burning and lubricating, for the manufacture of hair oils, soaps and ointments, for oiling leather and wool and in dyeing (compare "OIL MORDANTS" and "TURKEY-RED DYEING").

Omorol. A silver proteid compound soluble in water. Used for local application in diphtheria and inflammation of the tonsils.

Opium and opium alkaloids. Opium is the dried latex obtained by scratching the unripe capsules of the poppy (*Papaver somniferum* L.). Opium is brown, soft and kneadable when fresh, later becomes brittle so that it may be powdered. It has a peculiar smell and bitter taste.

The effect of opium is due to the various alkaloids contained in it. The opium alkaloids are classified according to PICTET as follows:

1. **MORPHINE GROUP.** Very poisonous bases containing an oxazine ring:



Pseudo-morphine $C_{17}H_{15}NO(OH)_2$
 Thebaine $C_{17}H_{15}NO(OCH_3)_2$

2. PAPAVERINE GROUP. These are not so active physiologically and are so far as is known iso-quinoline derivatives:

Papaverine $C_{16}H_{13}N(OCH_3)_4$
 Codamine $C_{18}H_{15}NO(OH)(OCH_3)_2$
 Laudamine $C_{17}H_{15}N(OH)(OCH_3)_3$
 Laudanidine $C_{17}H_{15}N(OH)(OCH_3)_3$
 Laudanosine $C_{17}H_{15}N(OCH_3)_4$
 Tritopine $C_{21}H_{27}NO_3$
 Meconidine $C_{21}H_{23}NO_4$
 Lanthopine $C_{23}H_{25}NO_4$
 Protopine $C_{20}H_{19}NO_5$
 Cryptopine $C_{19}H_{17}NO_3(OCH_3)_2$
 Papaveramine $C_{21}H_{21}NO_5$
 Narcotine $C_{19}H_{14}NO_4(OCH_3)_3$
 Gnoscopine $C_{23}H_{23}NO_7$
 Oxy-narcotine $C_{19}H_{14}NO_5(OCH_3)_3$
 Narceine $C_{20}H_{18}NO_5(OCH_3)_3$
 Hydro-cotarnine $C_{11}H_{12}NO_2(OCH_3)$
 Xanthaline $C_{37}H_{36}O_9$

Besides this opium contains MECONIC ACID $C_7H_4O_7$, with which the alkaloids are to some extent combined, and various other less important substances. Other constituents of opium are lactic acid, sulphuric acid, ammonium salts, mucin, pectin substances, albumin, caoutchouc, wax, &c.

The average percentage of the more important alkaloids is according to PICTET as follows: 9 % morphine (variations from 1.6—17 % have been observed); 5 % narcotine; 0.8 % papaverine; 0.4 % thebaine; 0.3 % codeine; 0.2 % narceine.

According to MERCK'S process morphine is prepared by extracting opium with H_2O . The aqueous extract is evaporated to the consistency of syrup and mixed with Na_2CO_3 which precipitates all the alkaloids. The precipitate separated after 24 hours is extracted with H_2O and then treated with cold alcohol which takes up all the accompanying alkaloids, resinous substances and a little morphine. The crude morphine is pressed and dried and then dissolved in dilute acetic acid to slightly acid reaction (during this process any narcotine which may be present remains undissolved as it forms no acetate). The acetic acid solution is filtered through animal charcoal and precipitated with ammonia. The separated alkaloid is collected on bags, washed with cold H_2O and dried. This precipitated morphine in the form of fine crystals is generally sufficiently pure for the preparation of its salts. To obtain it quite pure it must be recrystallized several times from boiling alcohol with the addition of animal charcoal.

Orange flowers, oil of. Obtained from the fresh flowers by distillation with steam or extraction with petroleum ether. It is a mobile liquid with a pleasant smell. It is at first colourless but becomes yellow or brown on standing. Two kinds are recognized viz. bitter and sweet. The former has S. G. (at 15°) 0.870—0.880; the later S. G. 0.893. The latter is used to adulterate the true or bitter oil of orange flowers. The constituents are not known with any certainty but synthetic preparations have been made which successfully imitate the natural product. Compare Germ. Pat. 122290 where the use of the methyl ester of anthranilic acid is described.

Orange peel, oil of. Two varieties, the bitter and sweet are recognized. **BITTER ORANGE PEEL OIL**, obtained by pressing the peel of the bitter orange.

Yellowish oil with a sharp burning bitter taste and orange-like aromatic odour. S. G. 0.848—0.854; B. P. 175—179°. $[\alpha]_D = (\text{circa}) + 95^\circ$. The oil contains limonene.

SWEET ORANGE PEEL OIL. More important commercially than the above described oil from which it differs chiefly in its milder and less bitter flavour. It is pale yellow in colour, S. G. 0.848—0.852. $[\alpha]_D$ at 20° = + 96° to + 98°. Used in the preparation of lemon essence.

Orchid oil (Ylang-Ylang oil, *Oleum anonae*, *Oleum unonae*.) This essential oil is not prepared from orchids but from the flowers of the tropical *Anona* (*Anona odoratissima*.) S. G. (at 15°) 0.940 to 0.955. Much used in perfumery on account of its fine odour.

As a substitute for the natural product the following recipe is given in Germ. Pat. 142859. Parts:—Linalool 250, geraniol 130, cadinene 50, eugenol 2, methylester of p-cresol 10, methylbenzoate 60, benzylalcohol 150, benzylacetate 100, benzylbenzoate 67, iso-eugenol 20, cresol 1, methylester of iso-eugenol 40, methylester of eugenol 100, methylsalicylate 20, and methylester of anthranilic acid 0.5. (This is only an example of the preparation of a synthetic product.)

Ores, preparation of. The various methods of separating different minerals, or of enriching the ore by removing useless parts comprise the mechanical preparation of ores. The ores are crushed, sorted, washed, &c. Recently preparation by means of oil and by magnets has become important.

MAGNETIC PREPARATION. The material is passed between electromagnets in the form of rollers or wedges. The effect is based on the magnetic properties of the material, the possibility of separation being due to paramagnetic (positive) and diamagnetic (negative) particles. Magnetic preparation allows of separating diamagnetic from paramagnetic substances, and also of separating paramagnetic substances from each other. Under the influence of very strong magnets all paramagnetic substances may be removed from a mixture with non-magnetic substance and be collected separately. As most minerals and moreover most ores are paramagnetic this method of preparation is very widely applicable.

By magnetic means the following ores may be extracted: All iron ores, compounds of titanium, tungsten, nickel, cobalt, manganese ores, sulphide and oxide of copper, and in short all ores containing a little iron, nickel, cobalt, titanium and tungsten; non-magnetic ores on the other hand are: lead and silver ores, tinstone, bismuth compounds.

The following are also magnetic:—All silicates, phosphates and carbonates containing manganese and iron; non-magnetic:—Silicic acid, heavy spar.

These processes of separation are chiefly dry methods so that they will be of great use where wet separations are difficult on account of scarcity of water or low temperatures.

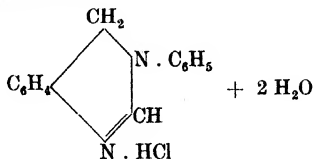
The Germ. Pat. 144954 purposes an oxidizing roasting as a preparation for poor iron ores before the magnetic treatment is applied. A similar treatment is the substance of the Engl. Pat. 6811 (1903).

The preparation of ores with oil invented by ELMORE, involves the use of heavy oils, especially the residues from petroleum distillation. When ores are crushed, large amounts are frequently lost in the shape of fine scales which float on the water. ELMORE therefore grinds the ore in a wet state and passes it with oil into a rotating cylinder where it is intimately mixed with the oil. This mixture is then separated from the excess of liquid and the oil finally removed by centrifugal appliances. The process is especially suitable for pyrites and copper ores. — Very similar to this is FROMMENT's process for preparing sulphur ores (Cu; Pb; Zn, &c.) with oil.

Ore dressing Machinery:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Orexine. Formerly this name was given to orexinehydrochloride = phenyl-dihydroquinazolinehydrochloride:—



It is prepared according to the Germ. Pat. 51712 from formanilide. By the action of metallic Na on the solution in benzene, sodium formanilide is obtained which is converted into o-nitrobenzyl formanilide by treating with o-nitrobenzyl chloride; this is reduced with Sn and HCl, o-amidobenzylformanilide is formed as an intermediate product and this is transformed into phenyldihydroquinazoline with separation of H₂O.

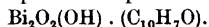
At present neither the hydrochloride nor the free base is used; instead of them the tannic acid salt is employed. It is prescribed medicinally to increase the appetite. The dose for adults is 0.5—1.0 g, and for children 0.25—0.5 g, once or twice a day, one or two hours before a meal.

Organic dyestuffs. See "VEGETABLE DYESTUFFS", "ANIMAL DYESTUFFS", and "COAL-TAR DYESTUFFS". The latter article gives a classification of coal-tar colours.

Orchil (Persio). Obtained from various coloured lichens (particularly *Roccella tinctoria*) by the method used in the preparation of litmus. Different varieties are prepared, e.g. ORCHIL PASTE, ORCHIL EXTRACT, FRENCH PURPLE and PERSIO (red indigo).

The paste is obtained by fermenting the lichens in presence of NH₃; the extract by heating with lime water and precipitating the colouring matter with acids; French purple is obtained as a lime compound from the colour solution; Persio is the dried extract and is obtained in the form of a powder. The essential constituent of orchil is a substance ORCEINE which dissolves in alkalis to give a violet coloured solution. It is used for dyeing wool and occasionally silk. Violet to dark-red shades are obtained without the use of mordants but the colour is very fugitive.

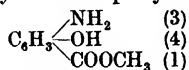
Orphole. A bismuth β-naphthol compound.



Odourless and tasteless brown powder, insoluble in H₂O and alcohol. It is used medicinally, internally as an intestinal antiseptic, externally as a substitute for jodoform.

Orthochromatic plates see "PHOTOGRAPHIC PLATES".

Orthoform (-New). Methyl m-amido-p-oxybenzoate.



Methyl p-oxybenzoate is nitrated and the nitro compound reduced.

It is a fine white powder M. P. 142°, very sparingly soluble in H₂O and ether, easily soluble in alcohol and boiling benzene. It is used as a local

anaesthetic with great success, for instance for gatherings, burns and wounds, in dental surgery for painless extraction, as an inhalation for colds, hay fever, &c. &c.

Orthotoluene sulphamide see "TOLUENE SULPHAMIDE".

Ortol see "PHOTOGRAPHIC CHEMICALS".

Osmium. Os. Atomic weight = 190.8. One of the platinum metals which separates from fused tin in very hard blue crystals. It also forms a grey black powder with a S. G. 22.48 and has M. P. *circa* 2500°. It is the heaviest of all elements and the most difficult to melt. When finely powdered it dissolves in various mineral acids. On the other hand compact Os is insoluble even in *Aqua regia*. It oxidizes on being heated in the air. An alloy of osmium and iridium is used for the points of pens, for fountain pens, and for other articles; its extreme hardness and its resistance to acids make it very valuable for such purposes. Osmium is also the material from which the incandescent body of the new AUER electric incandescent lamps are made. Compare OSMIUM LAMPS.

Compare PLATINUM for the process for obtaining colloidal osmium as given in the Germ. Pat. 157172.

Osmium:

Johnson Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Osmium compounds. Osmium tetroxide, wrongly called osmic acid is formed by heating Os in the air or in steam and also by treating Os with HNO_3 or *Aqua regia*.

A white crystalline substance (needles) which sublime easily, B. P. 100°, readily soluble in water. Osmic acid volatilizes in dilute solutions; the vapours are very poisonous and have a pungent smell. They attack the mucous membrane very readily. Osmates corresponding to the unknown OsO_3 have been obtained.

Osmic acid is used for hardening animal tissues for microscopic work.

Osmium compounds:

Johnson Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Osmium lamps. This name has been given to the incandescent electric lamps invented by AUER. The osmium is worked up with other materials to a dough-like substance and made into threads under pressure. After these are dry, they are reduced by an electric current to pure metal. The osmium filaments are enclosed in vacuous glass bulbs, or in bulbs filled with some indifferent gas, on the same principle as the ordinary electric incandescent lamps.

The osmium lamps only use 1.5 watt for 1 candlepower. It is a disadvantage that the lamp burns at such a low EM. F. 25 candlepower lamps need between 25 and 30 volts; those of 30—35 candlepower about 38 volts, so that several lamps have to be coupled together when the usual voltage of 110—120 volts is supplied. The osmium lamps are also expensive, on account of the rarity of the metal, the price being 5 shillings each, but on the other hand they last for 1500 burning hours and repay the expense in the economy of current. The light is a brilliant white.

The following table gives the illuminating power and amount of current of the osmium lamp when burnt continually. The numbers which are averages speak for themselves:—

Time of burning in hours	Strength of current in Amperes	Average Strength of light in Candlepower	Energy required in Watts per candlepower
100	1.348	35.25	1.454
400	1.320	33.27	1.510
800	1.288	31.50	1.554
1000	1.272	29.95	1.617

A further advantage of the osmium lamps is that they are so little affected by variations of voltage and do not flicker and flare as do the carbon filament lamps. There is scarcely any perceptible blackening of the glass from the osmium so that the lighting power is not affected.

The price of the osmium lamps of 16—32 candlepower is 5/6. Of this nine pence is returned for the worn-out lamp. As the lamp does not need half the energy necessary for carbon filament lamps, it can be easily calculated that with a current costing (for instance) 5 pence per kilowatt a 32 candle-lamp pays for itself in about 170 burning hours. Taking as a standard the time a carbon lamp burns, at about 800, we have for the rest of the 600 burning hours, a saving of 18/ worth of current.

Osmosis see "DIFFUSION".

Osram lamps see "TUNGSTEN LAMPS".

Ovogal. A combination of ox-gall and egg-albumin which passes unchanged through the stomach and dissolves in the intestine. It is a powder with an unpleasant taste prescribed as a cholagogue.

Oxalates see under the respective metals.

Oxalic acid. $C_2H_2O_4$. Occurs in various plants, e. g. sorrel, rhubarb, &c. It is obtained artificially by treating many carbon compounds (sugar, starch, cellulose) with HNO_3 or fused potash. It may be prepared by heating 1 part cane sugar with 8 parts HNO_3 . On a large scale it is obtained as follows:—

1 part of saw dust, from which the large pieces have been removed by passing through sieves, is soaked with caustic lye (S. G. 1.3—1.4). (The lye is a mixture of KOH and NaOH.) The saw-dust and alkali are heated to 240° in shallow pans with constant stirring, the thickness of the layer being about 2 cm. The heating is continued until a greenish-yellow melt is obtained. While still hot the melt is thrown into warm water, the extract evaporated (to 38 Bé) and allowed to cool. The greater part of the sodium oxalate then separates out. It is removed from the solution, dissolved in a small quantity of boiling water and the oxalic acid precipitated with lime. The calcium oxalate is made into a thin paste with water, heated and the calcium precipitated with H_2SO_4 . The solution of oxalic acid is further evaporated until the last portions of $CaSO_4$ have separated and is then crystallized and purified by recrystallization.

Oxalic acid is also obtained commercially by treating saw-dust with a mixture of HNO_3 and H_2SO_4 .

According to Germ. Pat. 183022 carbohydrates are oxidized with HNO_3 in presence of small quantities of vanadium compounds (usually V_2O_5) which act as oxygen carriers. The advantages claimed for this process are:— The whole process is carried out without any external heating in a shorter time, no intermediate products are formed and the yield is considerably greater.

Since the preparation of formic acid (q. v.) by GOLDSCHMIDT's patented process can now be carried out so cheaply oxalates are now prepared (Germ.

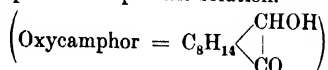
Pat. 111078) by heating mixtures of formates and carbonates. An important modification is described in Germ. Pat. 161512; see potassium oxalate under POTASSIUM COMPOUNDS. The free acid can be obtained from the salts.

It forms colourless transparent crystals with $2\text{H}_2\text{O}$. The crystals which have a strongly acid taste, are odourless and effloresce in the air. They dissolve in 12–14 parts cold water and in 0.3 to 0.4 parts hot water. Oxalic acid is poisonous. It is used in dyeing and calico printing, for the preparation of formic acid, rosolic acid, dextrine and diphenylamine blue, for bleaching straw, for the purification of stearine and glycerine, for removing inkstains and iron-mould, for the polishing of brass (under the name of sugar acid), &c. &c.

Oxalic acid:

Domeier & Co., 8 Harp Lane, London E.C.

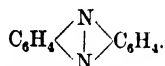
Oxaphor = oxycamphor in 50 percent solution.



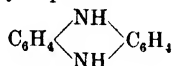
Oxycamphor is obtained by the reduction of camphorquinone $\text{C}_8\text{H}_{14}(\text{CO})_2$ by means of zinc dust and acids; the oxycamphor formed is extracted from the liquid and purified by distillation in steam.

White crystalline powder M. P. 203–205° C, sparingly soluble in cold, more readily in hot H_2O , very easily soluble in all organic solvents. Since solid oxycamphor decomposes on keeping, only the 50 % solution is sold. Oxaphor is given internally in all kinds of respiratory diseases; single dose 1–1.5 g, dose per day 1.5–2 g.

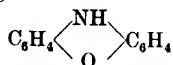
Oxazines and thiazines. Two closely related classes of coal-tar colours. They are derived from the azine dyes (q. v.) of which the simplest representative is phenazine



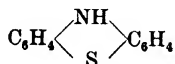
Phenazine on reduction gives hydrophenazine



By substituting an imide group (NH) in hydrophenazine by O, an oxazine is obtained, i. e. phenoxazine

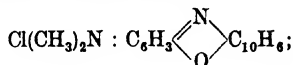


while by substituting NH by S the simplest thiazine, viz. phenothiazine (thiodiphenylamine)



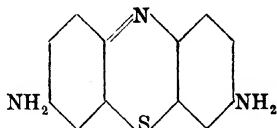
is obtained. Oxazine dyes are derived from phenoxazine, and thiazine dyes from phenothiazine. The former possess the chromophore group $\begin{array}{c} \text{NH} \\ \diagup \quad \diagdown \\ | \\ \text{O} \end{array}$ or rather $\begin{array}{c} \text{N} \\ \diagup \quad \diagdown \\ | \\ \text{O} \end{array}$, while the chromophore group $\begin{array}{c} \text{N} \\ \diagup \quad \diagdown \\ | \\ \text{S} \end{array}$ is assumed to be present in the thiazines (also called thionine dyestuffs).

Naphthylene blue (New blue, cotton blue) is of this class. Its constitution is dimethylphenylammonium naphthoxazine



it is obtained by condensing nitrosodimethylaniline hydrochloride with β -naphthol in alcoholic solution in presence of zinc chloride.

The simplest representative of thiazines is LAUTH'S violet (Thionine) now no longer used:—



obtained by the oxidation of p-phenylenediamine in acid solution with FeCl_3 in presence of H_2S . Especially important in this class is methylene blue, an alkylated thionine (see "METHYLENE BLUE").

Oxybenzoic acid see "SALICYLIC ACID".

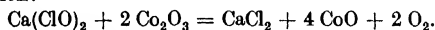
Oxycellulose. Obtained by the action of different oxidizing agents on cellulose. For instance oxycellulose is prepared in the form of a fine paste by boiling 85 g of loose cotton with 65 ccm of soda lye of 7° Bé and a solution of 12 g of KMnO_4 in 1750 ccm of water till the whole loses its colour. It is then filtered, washed while still hot, allowed to drain, then treated with soda lye of 25° Bé at 50° C, and allowed to stand till the following day. This paste is used for obtaining a damask effect in the cotton industry, especially by employment as a dressing for satens.

Further, oxycellulose can be made by boiling filter paper with $2\frac{1}{2}$ times its weight of HNO_3 (S. G. 1.3). According to this method β -oxycellulose substances are obtained which differ in various ways from the γ -oxycellulose products. (Compare Chem.-Ztg., Repertor. 1901, p. 353). Allied to these substances are those which pass under the name of hydrocellulose products, which were first made by GIRARD by warming cellulose with hydrochloric acid. Hydrocellulose is obtained (Germ. Pat. 123122) in a much shorter time by adding a quantity of potassium chlorate, insufficient for converting cellulose into oxycellulose, in the treatment of cellulose with HCl , and maintaining a reaction temperature of 60–70°. The very small quantity of KClO_3 gives the hydrocellulose peculiar qualities. It forms a white powder, which is sandy to the touch, is proof against acids and alkalis, and can therefore be employed for making articles for which these last named characteristics are of importance. According to Germ. Pat. 123121 a different form of hydrocellulose is obtained by adding crude cellulose to glacial acetic acid containing free chlorine, and heating to 60–70° with constant stirring. This form of hydrocellulose is said to be employed as an intermediate substance in the manufacture of acetyl- and nitro derivatives.

According to Germ. Pat. 137206 a hydrocellulose containing sulphur is formed by adding HCl to the hydrocellulose obtained in the manner described by Germ. Pat. 123122. Chloride of sulphur is added to this semi-liquid mixture, when the product of the reaction is poured into H_2O in order to separate the sulpho-hydrocellulose. This substance is very valuable for vulcanizing caoutchouc more particularly because the cellulose as well as the sulphur enters into chemical combination with the rubber.

Oxydasine. An antiseptic recommended for wounds and gatherings; it consists chiefly of a 0.05 % solution of vanadic acid.

Oxygen. O. A. W. = 16.00 (H = 1.008). Obtained by heating KClO_3 ; better with additions of MnO_2 which should be pure. A better substitute for MnO_2 as an addition to the KClO_3 , is freshly precipitated and ignited Fe_2O_3 (caput mortuum). O is also obtained by heating MnO_2 with H_2SO_4 in retorts, or by decomposing a mixture of these two substances in suitable vessels by means of an air current under pressure; in the latter case no heat is required. Another method is based on the fact that bleaching powder evolves O when treated with the oxides of Ni, Co and Cu; Co_2O_3 is generally used: A clear concentrated solution of bleaching powder solution is heated to $70\text{--}80^\circ\text{C}$ with 0.1—0.5 % of its weight of Co_2O_3 or by a more simple process, Cl is passed into thick milk of lime containing a cobalt salt. The transformation is the same in either case, corresponding to the following equation:



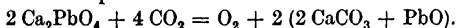
The advantage gained by the fact that the CoO formed is always able to take up O with re-formation of Co_2O_3 is neutralized by the conversion of the bleaching powder into CaCl_2 , i. e. the former must be constantly renewed.

According to Germ. Pat. 143548 pure O is obtained from sodium peroxide. The Na_2O_2 in the form of cubes is mixed with a little Ni- or Cu-salt and then brought in contact with H_2O , in a KIRP's apparatus; the decomposition takes place with formation of NaOH and O.

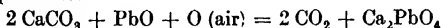
All these methods are too expensive for industrial purposes. The most promising methods appear to be those which utilise the atmospheric O. Five methods of obtaining oxygen from the air have been proposed:—

1. When barium peroxide BaO_2 is heated to 800°C it evolves oxygen: $\text{BaO}_2 = \text{BaO} + \text{O}$ (at 800°). When a current of pure air¹⁾ is conducted over the resulting barium oxide (BaO) at $500\text{--}600^\circ\text{C}$ it again takes up oxygen from the air:— $\text{BaO} + \text{O} = \text{BaO}_2$ (at $500\text{--}600^\circ$) that is theoretically the same amount of barium oxide remains active, the oxygen being obtained from the air.

2. According to KASSNER oxygen may be obtained by passing pure carbonic acid over calcium orthoplumbate:

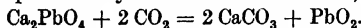


By conducting air over the latter compound it is reconverted into the original orthoplumbate

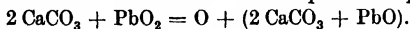


Theoretically both the calcium salt and the CO_2 are regenerated in constant quantities. The same principle is that of the following.

3. The calcium orthoplumbate is converted while moist into calcium carbonate and lead peroxide by dilute carbon dioxide²⁾:



When the latter mixture is heated the lead peroxide splits off oxygen:



The regeneration of the last named mixture to calcium orthoplumbate is precisely the same as described above.

4. It has been proposed to fractionate air by diffusion through plates of plaster of Paris. The nitrogen passes through a porous substance more rapidly than the heavier oxygen. The air which passes through contains therefore more nitrogen and the remaining portion more oxygen. Although

¹⁾ The air must be freed from CO_2 by passing through caustic soda solution.

²⁾ Furnace gases containing carbon dioxide are used.

theoretically any percentage of oxygen may be thus obtained, it appears evident that the method is hardly capable of practical application.

5. Another method of obtaining oxygen from the air is based on the fact that nitrogen is less soluble in water than oxygen:

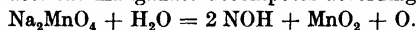
1 vol. water will dissolve	0.4114 vol. oxygen
1 " " " " "	0.2035 " nitrogen

at 0° C under 760 mm mercury.

When therefore water is allowed to absorb air and the absorbed mixture of gases is expelled by heat it contains more oxygen than the original air. If this mixture is then conducted into cold water again, and again expelled and this operation repeated several times, the gas mixture contains considerable amounts of oxygen, so that for industrial purposes it is equivalent to pure oxygen. This latter method was expected to prove a valuable one, but the expense of the process has turned out to be very considerable. Of the various methods enumerated, so far as the author is aware the only ones used, on a large scale are the first, originally suggested by BOUSSIGNAULT and improved by the BRIN BROTHERS, and the second, invented by KASSNER and based (like the third) on the decomposition of calcium orthoplumbate.

6. The methods of obtaining O from liquid air will probably become highly important. For LINDE'S process see "AIR, LIQUID". The method has now attained considerable importance. The air is first completely liquefied and then allowed to evaporate. The more volatile N escapes first and a gas containing 95 % O is eventually obtained. By lessening the yield a purity of 98—99 % may be reached. The cost is relatively low. PICTET'S method for separating atmospheric O and N by thermo-mechanical means belongs to this category. The patents taken out for this process (Engl. Pat. 19254, 1900), French Pat. 322600 with supplement and Germ. Pat. 162323) protect the following points: 1. The air is filtered, compressed and freed from water. 2. The dry, compressed air is cooled to the point of solidification, i. e. about — 194° C. 3. The liquefied air is filtered to remove the floating particles of carbon dioxide. 4. The filtered liquid is again evaporated, the more volatile nitrogen escaping first. 5. The cold produced by the evaporation of the liquid air is utilized to liquefy the compressed air pumped into the apparatus. 6. An automatic arrangement insures continuous working. 7. Another automatic arrangement ensures that the nitrogen and oxygen leave the apparatus of the required degree of purity; and also prevents gas mixtures escaping which differ but slightly from ordinary atmospheric air. — PICTET'S apparatus consists of two boxes, the larger serving to accumulate the N and the smaller the O. The lower part of the former contains a liquid bath of liquefied air with coils through which cold compressed air may pass. The temperature in the bath is such that on the whole only N escapes while the percentage of O in the liquid increases. The liquefied air enters the second box which is arranged much like the other. The solid CO₂ is removed by filtering and the filtrate used to begin the liquefaction of the air entering the first box. As this becomes warm, it loses N which escapes in almost a pure condition. In a similar way the O is obtained in the smaller box.

7. Germ. Pat. 134134 is probably of little industrial value; the process consists in allowing air and steam to act alternately upon alkali manganates. When the steam acts the manganate decomposes according to the equation:



The caustic alkali and manganese dioxide thus produced are now able to absorb a further quantity of O. The details of the process are beyond the scope of the present book.

8. The electrolytical production of O is already of great importance, H₂O or aqueous solutions of salts are decomposed. This process known for a long

time has been adapted to industrial application. Iron or carbon electrodes are used while the liquid consists of soda lye or a solution of K_2CO_3 ; the O is collected at the anode and the H separately at the cathode. There are many variations in detail in the electrolytical production of O, but no fundamental differences.

9. The method mentioned above of producing O from bleaching powder has been the subject of attempts to adapt it to industrial requirements. The process given by JAUBERT (Engl. Pat. 21122 (1903), Engl. Pat. 26148 (1903), Germ. Pat. 157171) improves the method considerably by adding certain contact substances, e.g. ferrous salts and manganous salts; small quantities of Cu-, Co-, or Ni-salts are also added to start the reaction. The mixture is placed into a gas developer, either as a powder or pressed into cubes, and as soon as H_2O is added the evolution of O commences. According to JAUBERT's latest reports it is advantageous to mix only the dry bleaching powder with $CuSO_4$, $CoSO_4$ or $NiSO_4$ and not to add the solution of $FeSO_4$ or $MnSO_4$ before use.

10. For preparing small quantities of O (French Pat. 336062 and supplements) the action of boric acid on peroxides is used, perborates (q. v.) are formed, which evolve free oxygen in contact with permanganates.

Oxygen is transported in seamless steel cylinders tested to 100 atm. pressure. O is a colourless, odourless and tasteless gas, S. G. 15.96 ($H = 1$), and 1.106 (air = 1). Critical temperature -119° , critical pressure 50 atm. Liquid O is light blue to steel blue in colour, S. G. 1.124 ($H_2O = 1$) and boils at $-182^\circ C$ under 760 mm.

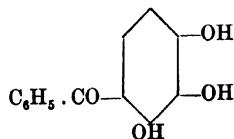
O has recently been used instead of air in various furnace processes, for melting and clarifying glass material, in the manufacture of SO_3 , and for regenerating the waste from gas purification (see "COAL GAS"). See also "OXYHYDROGEN GAS" and "OZONE".

Oxyhydrogen gas. A mixture of oxygen and hydrogen which explodes violently on ignition with the formation of water: the explosion is most violent when the gases are mixed in the proportion $H : O = 2 : 1$. If the two gases be contained in separate vessels and be ignited at the common point of issue no explosion results. The flame thus produced is small and non-luminous but intensely hot. It is in consequence used for melting platinum, for soldering metallic plates and for giving DRUMMOND's lime-light.

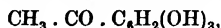
Instead of hydrogen coal gas is sometimes used, and similarly air takes the place of oxygen in this mixture, but in neither of these cases is the same temperature attained.

Oxyketone dyestuffs. This very important group of coal-tar colouring matters includes the monoketone colours, the oxyxanthenes, and the diketone dyestuffs.

The monoketone colours contain two or more salt forming OH groups in addition to the chromophore CO group. They are produced by the condensation of aliphatic and aromatic monocarboxylic and oxyacids, or their chlorides, with phenol in presence of $ZnCl_2$, concentrated H_2SO_4 or $SnCl_4$. They give yellow shades. To this class belong, for instance, alizarine yellow A and alizarine yellow C. Alizarine yellow A is trioxymethylphenone

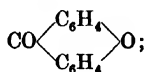


and is produced by the action of benzoic acid or benzotrichloride on pyrogallol in presence of zinc chloride. Alizarine yellow C is gallacetophenone

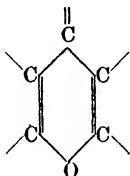


that is, it differs from alizarine yellow A, in that the benzyl group is replaced by the acetyl group. It is produced by the action of acetic acid and zinc chloride on pyrogallol.

The oxanthones are oxyderivates of the diphenylene ketones (xanthones)



a characteristic of this colour group is the ring



To this class of colouring matters belong various natural pigments, e. g. the euxanthone of Indian or Chinese yellow (compare "ANIMAL DYE STUFFS"). The artificial dyestuff which has been given the name of galloflavine should be included in this group (its constitution is, however, still unknown). This substance is obtained by the action of atmospheric oxygen on an alkaline solution of gallic acid.

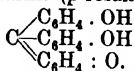
The diketone dyestuffs contain two CO groups each in the p-position and in addition at least 2 hydroxyl groups, which stand to each other in the o-position and are next to the CO group. As these very important colouring substances are all derivatives of anthracenes or anthraquinone, they have been given the names anthracene, anthraquinone or alizarine colours. Most of these substances are mordant dyestuffs, that is they unite with metallic oxides to form on the fibres a coloured lake which is very fast. The most important diketone colour is undoubtedly alizarine. See "ALIZARINE". It forms an orange-coloured paste and dyes cotton, mordanted with aluminates, red, with zinc, rose, and with chromium, Bordeaux, while on an iron mordant the colour obtained is violet. The most important use this substance is put to however, is as a substitute for madder in Turkey red dyeing. Compare the article on "TURKEY RED DYEING". Mention should also be made of another diketone dye to which has been given the name of "PURPURINE". The constitution of this colour is 1, 2, 4-trioxanthraquinone. It is obtained by the oxidation of alizarine with $\text{MnO}_2 + \text{H}_2\text{SO}_4$ or electrolytically on the cathode from a mixture of anthraquinone and fused KOH. Purpurine dyes cotton mordanted with aluminate a bright scarlet and cotton treated with a chromium mordant a shade of red-brown or Bordeaux red.

Oxytriphenylmethane dyestuffs. Coal-tar dyes which belong to the triphenylmethane series (q. v.).

In the rosaniline dyestuffs (see "AMIDOTRIPHENYLMETHANE DYE STUFFS") the amido groups are substituted by hydroxyl groups. They therefore contain the chromophore $=\text{C}-\text{R}-\text{O}$ or $=\text{C}=\text{R}=\text{O}$ where the C atom and



O atom in the phenyl group R are in the p-position. The simplest representative of this group is aurine (p-rosalic acid)



It is formed when phenol is heated to 120–130° with oxalic acid and sulphuric acid.

Oxyxanthones see "OXYKETONE COLOURS".

Ozokerite. A mineral of a waxy nature generally black, green or brown in colour. It is sometimes as hard as gypsum. Ozokerite is a mixture of solid and liquid hydrocarbons and occurs in a massive state. S. G. 0.85–0.95. M. P. lies between 60° and 70°, though sometimes it varies between 55 and 110° C. Ozokerite is chiefly used in the preparation of ceresine.

TEST. The impurities in crude ozokerite are mineral substances, water, and mineral oils. The examination covers, a) the residue insoluble in petroleum ether (ash), b) the loss of weight at 150° C, which should not exceed 5 %, and c) the melting point. When ozokerite is adulterated with colophony there is an acid index. E. v. BOYEN in the Zeitschr. f. angew. Chem. 1898, 383 gives more details concerning ozokerite.

Ozone. A condensed form of oxygen, O₃, which readily gives up the third atom of O and can therefore be regarded as one of the most effective means of oxidation.

For industrial purposes the only method of preparation is that first described by W. SIEMENS in 1857, viz. the silent electric discharge. The old SIEMENS ozone tube is not used as much now as the newer ozone mica tube, consisting of a metal tube covered with mica which is surrounded by a second metal tube lined with mica. The gas to be ozonized (usually air, less frequently oxygen) is passed between the two mica tubes which are connected by their respective metallic surfaces with the poles of a RUHMKORFF induction machine. Other modifications (e. g. the SIEMENS & HALSKE apparatus) consist of two glass tubes one inside the other and fused together in a particular way so that the air to be ozonized passes through between the two; the inner tube is filled with acidified water and the whole apparatus placed in water so that the two coverings of this condenser consist of water. In addition to glass and mica other di-electrical materials have also been used in the construction of ozone apparatus. Part of the oxygen passing through the apparatus is converted into active oxygen; it is essential that the gases to be ozonized should be dry and free from dust.

According to the Germ. Pat. 134929 highly ozonized air is produced by repeatedly conducting the same gas through the discharge space of an ozone apparatus. The air is driven or drawn repeatedly through the ozone apparatus while the air consumed is replenished automatically by a valve.

The Germ. Pat. 140316 protects an ozone apparatus in which phosphorus in the form of a candle is dipped into a suitable liquid; a short piece only of the P projects above the liquid and this is constantly pressed against a cover placed above the liquid, so that a continuous formation of ozone occurs.

Germ. Pat. 187493 protects the application of a method known for a long period. Aqueous liquids are electrolyzed with non-conducting electrodes which are kept cool. Gas containing 30 % ozone can be prepared by this means.

Though the production of ozone cannot be described as cheap it is nevertheless becoming commercially important. It is used to bleach woven materials, to mature spirits, to improve tobacco, to bleach oils, to purify starch, to sterilize drinking water, &c. See "BLEACHING", "FATS AND OILS", "SPIRITS", also "WATER PURIFICATION".

P

Painter's canvas.**Painter's canvas:**

D^r. Fr. Schoenfeld & Co., Düsseldorf, Germany.

Painter's colours. Oil colours are usually mixed with linseed oil, sometimes with an addition of varnish or wax. In resinous oil colours, the linseed oil is sometimes replaced by amber or copal varnish, or by copaiva balsam. The petroleum colours contain besides a certain quantity of this substance, considerable proportions of linseed oil and amber varnish. Water colours differ in principle from oil and varnish colours, the adhesive used being gum Arabic solution, and in some cases prepared ox-gall and glycerine. Caseine colours are mixed with caseine; distemper colours are mixed with yolk of egg with or without the white of egg and acetic acid.

The "Münchener Gesellschaft zur Förderung rationeller Malverfahren" gives a list of pigments which are lasting and have no bad influence on each other. These so-called normal colours are as follows:

Zinc white.

Naples yellow, light and dark.

Cadmium yellow, light, dark and orange.

Indian yellow, Chinese yellow.

Light ochre, dark ochre, gold ochre, Terra Sienna. Native or burnt, in all cases.

Umber, native or burnt.

Iron oxide, English red, &c.

Terra Pozzuoli.

Vermilion, cinnabar.

Madder, rose, dark, violet.

Ultramarine.

Cobalt blue.

Paris blue.

Cobalt green.

Chromium oxide green, real.

Chromium oxide green, emerald green.

Green earth, native and burnt, Bohemian and Veronese.

Asphalt (sparingly).

Ivory black, vine black, Frankfort or German black.

Painter's colours:

D^r. Fr. Schoenfeld & Co., Düsseldorf, Germany.

Dr. Roth's Inertol:

Paul Lechler, Stuttgart, Germany.

Palladium. Pd. A heavy metal, belonging to the group of "PLATINUM METALS" (q. v.). Atomic weight = 100.3; S. G. 11.8; M. P. 1700°.

Palladium dichloride, PdCl₂, is of some importance as it is used in analysis for the estimation of carbon monoxide. Pd is used commercially for the manufacture of "silver foil".

For Germ. Pat. 157172 on colloidal palladium, see "PLATINUM".

Palladium and Compounds:

Johnson Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Palmitacol see "CETYLGLACYL".

Palmitic acid (n-hexadecylic acid). $C_{16}H_{32}O_2 = CH_3(CH_2)_{14} \cdot CO_2H$.

It is a constituent of most animal and vegetable fats in the form of glycerides; chiefly obtained from palm oil by saponifying the latter, decomposing the soap and purifying the palmitic acid by fractional crystallization. It is a soft friable white powder crystallizing from alcohol in scales or needles. M. P. $32^\circ C$. B. P. $339-356^\circ$ (with partial decomposition); under a pressure of 100 mm mercury the boiling point is $268.5^\circ C$. The commercial product is frequently called palmitine. The palmitates of the alkali metals (soaps) dissolve in alcohol without decomposition, but with excess of H_2O they are split into alkali and acid salt (which separates out). The other palmitates are as a rule soluble in H_2O and partly soluble in alcohol.

Palm oil. An oil obtained from the fruit of the oil palm (*Elaeis guineensis*; *Avoira elais*). The oil is prepared in West Africa and South America by pressing the fruit or extracting with water. The exported fruit is sometimes subjected to hydraulic pressure and sometimes extracted with petroleum ether or CS_2 . When fresh the oil is colourless but it rapidly acquires a yellowish tinge. POHL's method for decolourizing the oil consists in heating it quickly to 240° .

The freshly prepared oil has a distinct odour of violets which is lost on exposure to the air. At lower temperatures it solidifies, the M. P. lies between 27° and 42.5° (according to the variety). S. G. $0.92-0.97$ (at 15.5°). Iodine number 51.1; S. G. of the fatty acids (at 100°) 0.839.

Palm oil is used largely in the manufacture of stearine candles and soap, as a lubricant, in Turkey red dyeing and in tin plating.

Palm wax see "VEGETABLE WAX".

Pancreon. A pancreatic preparation which passes through the stomach unchanged. In order that the pancreatine may not be destroyed by the pepsine of the stomach the substance is converted into a form insoluble in water and acids by treating it with tannic acid. The pancreatic action is not affected and the presence of 10 % tannic acid has no objectionable influence (Germ. Pat. 128419).

Pans.

Copper pans:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Papaverine see "OPIUM AND OPIUM ALKALOIDS".

Paper. Sheets which are prepared by the felting of fine fibres while in the wet state. The best paper fibres are obtained from rags, less valuable papers are obtained by using rag substitutes such as wood, straw, esparto, &c. The rags of flax and hemp supply the most durable papers; then follow cotton and finally half wool and half linen. Wood substitutes are used in the form of shavings as well as cellulose.

The manufacture of paper is carried out in three stages: 1. the preparation of the fibres, 2. the preparation of the paper material, 3. the finishing of the paper.

In the preparation of the fibres various operations are necessary—according as rags or rag substitutes are used. If the paper is made from rags the first stage may be split up into four phases, namely:

1. Sorting and cutting the rags.
2. Cleaning.
3. Tearing up the rags.
4. Bleaching.

The sorting of the rags is done by hand; it is preceded by a cleaning process which is carried out by means of a rag thresher, that is a machine provided with a peg drum.

For cutting the rags a cutter is used. The best are those which are fitted with vertical knives as then it is sufficient to pass the rags through the machine only once.

The further treatment of the cut rags is divided into a dry (mechanical) and a wet (chemical) cleaning.

For cleaning the cut rags a "rag duster" is employed. The chemical cleaning is carried out by boiling with alkaline liquids, e. g. soda, caustic soda and especially lime.

The third phase is the reducing of the rags to small pieces, that is, the preparation of the raw material; the process is subdivided into the preparation of the "half stuff" and the "whole stuff". Machines, in which rotating discs studded with knives tear the wet stuff, are almost exclusively used.

The preparation of the "wholestuff" is only a continuation of the last process; the washing is not carried out in the rag machine itself but in special drums.

The bleaching is now done almost always with chlorine. It is carried out preferably in special apparatus, which take about 750 kg stuff and contain 2 washing drums.

See "BLEACHING".

The manufacture of wood stuff and shavings is treated in the article "WOOD STUFF", that of cellulose and sulphite cellulose under "CELLULOSE".

In the second stage in the manufacture of paper, namely the preparation of the paper material, three phases can be distinguished:

1. Mixing, whitening, filling; 2. sizing; 3. colouring.

The mixing of different "whole stuffs" and the addition of substitutes depend entirely upon the kind of paper required. The bleaching must not be carried too far in order to preserve the structure of the fibres; on this account it is necessary under certain conditions to "blue" or "white" the material in order to attain a purer white. The first mentioned operation consists in the addition of ultramarine, the second in mixing with white clay (kaolin), or patent white, heavy spar, &c. As these substances at the same time level the paper by filling the pores this process is sometimes known as "filling".

The papers thus obtained from the materials are in all cases porous and absorb liquids (filter paper, blotting paper). If they are to be used for writing or painting they must be sized. A distinction is made between sizing in the material (before the formation of the paper) and sizing in sheets (after the making of the paper). The sizing in the material (tub sizing) is performed almost exclusively with gum (vegetable sizing); on the other hand the finished paper is almost always coated with animal size (surface sizing).

The last phase in the preparation of paper material is the colouring. Just as in sizing, so in colouring there is tub colouring and surface colouring (colouring in sheets).

As soon as the paper material is finished, the real paper making begins. The material is stirred with water to a milk or pulp of the requisite thickness, but from which the lumps, sand, &c., must be first removed. The material is then transformed into moist paper by removing the water and felting the fibres; the moist paper is then pressed, dried, ironed, cut, and sized.

All these operations are carried out by hand to a small extent only; the work is almost exclusively performed by machines.

See also "FILTER PAPER", "PAPIER MACHÉ" and "CARDBOARD".

TEST. To determine the ash 1—2 g paper are dried at 100—105° until the weight is constant, then carbonized in a platinum crucible, and heated

until the weight is constant; if lead compounds are present, the heating must be carried out in a porcelain crucible. REIMANN'S ash balance which gives results correct to 0.25 % is generally used. The presence of wood shavings can be shown by using an aqueous solution of aniline sulphate, which is turned golden yellow by paper containing wood shavings, or a solution of phloroglucine acidified with HCl which is turned red.

The thoroughness of the sizing can be determined according to the following method of LEONHARDI: A drop (about 3 cg) of iron chloride solution containing 1.53 % Fe is brought on to the paper to be tested and allowed to act as many seconds as the paper weighs grammes per square metre, and then the remainder quickly absorbed with blotting paper. After drying, the other side is painted with an aqueous tannin solution. If an immediate black colouration is the result, the paper is not well sized; with well sized papers no colouration takes place.

To test for resin size a few grams of paper are boiled with absolute alcohol and a few drops of acetic acid and the solution poured into distilled water; if the mixture turns milky resin is present. The presence of resin may also be shown by pouring a few drops of ether on the paper; if after evaporating, the places in question show a transparent edge resin is present.

Animal size may be tested for by boiling 5–10 g paper with as little distilled H₂O as possible, filtering the solution, evaporating down to a small volume, and adding a tannin solution; the formation of a greyish-white flaky precipitate shows the presence of animal size. To avoid mistakes as to this precipitate (starch also under certain conditions gives a precipitate with tannin solution) it is examined microscopically after the addition of iodine solution: size is turned brownish-yellow by this agent, and starch dark blue. The presence of starch may, however, also be shown by laying the paper in dilute iodine solution in which the paper turns light blue to dark blue according to the amount of starch present.

With regard to the microscopic testing of paper for the kinds of fibres contained in it, the following method of W. HERZBERG (LUNGE'S "Chemisch-technische Untersuchungsmethoden", Bd. III, Berlin 1900) may be given:

According to the thickness 2–5 square cm of paper are boiled for one or two minutes with dilute (2–4 %) sodium or potassium hydroxide and while as hot as possible well shaken several times. The pulp thus obtained is brought on to a fine meshed wire sieve and freed from lye by washing with water.

The preparation of the fibres is carried out by using an aqueous potassium iodide solution of iodine, or a zinc chloride iodine solution.

The iodine potassium iodide solution consists of 6 parts iodine, 10 parts potassium iodide, 10 parts glycerine, and 90 parts H₂O.

The zinc chloride iodine solution is prepared from 100 parts zinc chloride, 10.5 parts potassium iodide, 0.5 parts iodine, and 75 parts H₂O; after the resulting precipitate has settled the clear solution is decanted.

For the determination of the different sorts of fibres it is necessary to notice not only the colour, but also the structure and sizes of the separate fibres.

The mechanical testing of paper (the strength test) cannot be here fully described. It can only be mentioned that the tests must be carried out in both directions. (To find out which is the long and which is the cross direction in the paper, two strips equally long can be cut lengthways and crosswise from the one piece of paper and then both laid in water; the strip which expands most distinguishes the cross direction.)

The fibres are dyed as follows:

Machines for manufacturing paper:
Werner Pfleiderer & Perkins Ltd., Peterborough.

Fibres		Colouration in	
		Iodine KI solution	Zn Cl ₂ Iodine solution
Group I Rag fibres	linen, hemp, cotton	light to dark brown; thin lamellae almost colourless	light to strong wine red ¹⁾
Group II Cellulose fibres	wood cellulose straw cellulose and jute esparto	grey to brown grey partly grey, partly brown	blue to red violet blue to blue violet partly blue, partly wine red
Group III Woody fibres	wood shavings, raw jute, badly treated, cell stuffs straw stuffs	partly luminous yellow-brown, partly yellow, according to the thickness of the layers and degree of liquefaction partly yellow brown, partly yellow, partly grey	citron yellow to dark yellow partly yellow, partly blue partly blue violet

Paper Making: Recovery of caustic Soda:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Papier maché. Plastic substances made of paper stuff and binding materials and then moulded. Another kind is made by cementing together (with glue or other cementing agent) numerous sheets of paper. The objects after drying are varnished.

For laboratory purposes M. A. PETIT recommends the following. The material which consists of 85 % cellulose and 15 % rags is moulded and dried by hot air in iron cylinders. The dried material is then steeped in solutions of resin oils, again dried and treated with more oil. After the final drying vessels are obtained which are flexible, impenetrable and acid-proof.

Papyrus see "PARCHMENT PAPER".

Paraamidophenol see "PHOTOGRAPHIC CHEMICALS".

Paraffin. A wax-like substance which is obtained from American petroleum, from earth wax, shale oil, and tar (especially from brown coal-tar). The above mentioned raw products are first submitted to a fractional distillation in order to free them from lower boiling constituents. The residue is distilled under diminished pressure by passing in superheated steam. The distillate after cooling in filter presses is separated into two parts: the solid paraffin and the liquid paraffin oil. The cooling is now almost always carried out with the help of freezing machines, which renders it possible to obtain paraffin from much more dilute solutions than formerly. The crude paraffin is coloured yellow by the enclosed oils and colouring matters, and so cannot be directly used. On this account the cakes just as they come from the hydraulic press are melted repeatedly with 10–15 % benzine and pressed hydraulically at 80–200 atmospheres. The runnings from the first pressing are employed

¹⁾ If the fibres appear bluish the solution is too concentrated and must be carefully diluted with H₂O until the pulp turns red. If the cellulose fibres are coloured red and not blue the solution is too weak; it can usually be rendered usable by adding ZnCl₂; if this is not successful a new solution must be made.

further in the mixing and crystallization, while those of the subsequent pressings are used for the first pressing of a new portion. In order to remove the odour of benzene the paraffin is treated with high pressure steam in iron cylinders and mixed while still liquid with decolourizing powder; e. g. the residue obtained in the manufacture of prussiate of potash (to the extent of 0.5–3 %). Animal charcoal and finely-divided well-dried clay have also been used as decolourizing agents. To remove the decolourizing powder the liquid paraffin is filtered through paper and allowed to solidify in moulds.

Germ. Pat. 162341 for obtaining paraffin from brown coal-tar consists in distilling off the low boiling constituents, such as photogene, light paraffin oils, &c; the residue is then separated, after the crystallization of the paraffin, by means of the centrifuge and filter press into solid paraffin and the higher boiling tar oils. The decolourization of paraffin is to a large extent carried out technically with the so-called "decolourizing powder", which was formerly obtained in large quantities as a by-product in the manufacture of prussiate of potash. This powder contains 30–40 % animal charcoal, large quantities of SiO_2 and silicates, as well as small amounts of Fe_2O_3 . As prussiate of potash is now manufactured by other methods the supply of decolourizing powder would probably have failed were it not for the fact that several prussiate of potash factories still work according to the old method.

The American decolourizing powder is now much used; it consists of magnesium hydrosilicate, is very cheap, but possesses much smaller decolourizing power than that rich in animal charcoal derived from the prussiate of potash manufacture.

According to the method of refinement the solid paraffin is a white semi-transparent mass; the hardness and other qualities vary according to the origin and degree of purity. We can distinguish between soft paraffins M. P. 44–48°, S. G. 0.88–0.89, and hard paraffins M. P. 52–58°, S. G. 0.898 to 0.915.

It is used for impregnating marble, for dressing cloths, for rendering materials waterproof; making paper transparent and soaking matches, but the greater quantity of paraffin is used for making candles.

A special kind of solid paraffin is obtained from ozokerite and bears the name ceresine; by a special process of purification this yields the paraffin M. P. 74–80° which is used for pharmaceutical purposes.

The liquid paraffin commonly known as paraffin oil is an oily colourless liquid without taste and smell. S. G. 0.880–0.895. B. P. above 360°. The paraffin oil obtained from petroleum by fractional distillation has a S. G. 0.87–0.925. By treating with superheated steam its viscosity is increased, which renders it more valuable as a lubricant.

TEST. The crude paraffin mass is cooled to 2–3°C, pressed between filter paper or linen, and the melting point of the pressed and weighed paraffin determined. The method of HOLDE for the exact determination of paraffin can be recommended: 0.5–1 g substance is dissolved in ether in a test tube (20–25 mm wide), care being taken to avoid excess of ether. An amount of absolute alcohol equal to the ether taken is gradually added and at the same time the tube gradually cooled to –20 or –21°C. If the precipitated paraffin mass is still too pasty, a little more of the mixture of equal parts of alcohol and ether is added and the paraffin flakes filtered off at a temperature of –20°C. For this purpose the filtering funnel is fastened by a cork into an inverted tubulated glass bell jar, and the latter filled with a mixture of rock salt and ice so that the funnel is cooled from the outside. The filtration is aided by suction. The precipitate is then washed with a fresh quantity of the solvent which is also cooled, and finally washed with hot benzene into a weighed glass dish. The benzene is evaporated first on a gently heated, and afterwards on a boiling water bath, the dish is then carefully dried outside

and the residue kept in a drying oven for $\frac{1}{4}$ hour at 105° , and weighed after cooling in a dessicator. In the filtrate from the first precipitate the amount of paraffin must also be determined by again evaporating the solvent, and finally on account of the solubility of paraffin in alcohol-ether it is always necessary to add 1 % to the total percentage of paraffin formed.

HOLDE's method is, however, not applicable to soft paraffin; the method of EISENLOHR is then employed:— 0.5 g substance are dissolved in 100 ccm alcohol, 25 ccm H_2O added and the mass cooled to -18° or -20° . The paraffin is then filtered as in HOLDE's method and washed with alcohol (at -18°) of 80° Tralles until the filtrate no longer becomes milky on the addition of water. The paraffin is dried in a vacuum dessicator at $35-40^{\circ}$, about 6 hours are necessary for the substance to attain constant weight. Further it is necessary to determine the percentage of water and mechanical impurities in paraffin. For the important determination of the melting point the following process is usually employed (Hallenser method), as agreed upon by the "Verein für Mineralöl-Industrie".

A small beaker about 7 cm in height and 4 cm diameter is filled with water, heated to about 70° , and a small piece of the paraffin to be tested thrown on this warmed water — the piece must be so big that after melting it forms a circular mass about 6 mm in diameter. As soon as this becomes liquid a thermometer is dipped, by means of a contrivance determined upon by the "Verein für Mineralöl-Industrie", just so deep that the long mercury bulb is completely covered with water. As soon as a thin skin forms over the surface of the melted paraffin the solidifying point is read on the thermometer. During this operation the beaker must be carefully protected from draughts and the breath of the operator must not be allowed to affect the surface of the liquid. The melting point can also be very easily determined according to the general method in a capillary glass tube.

According to GRAEFE small amounts of ceresine in paraffin may be tested for by dissolving 1 g of the substance in question in 10 ccm CS_2 , and adding to 1 ccm of this solution 10 ccm alcohol-ether (1 : 1) at 20° . If a precipitate is formed which remains flaky after warming and cooling again, then ceresine is present.

Paraform see "FORMALDEHYDE".

Paraformaldehyde see "FORMALDEHYDE".

Paraldehyde. $(C_2H_4O)_3$. Ordinary aldehyde (q. v.) polymerizes under the influence of small quantities of acid giving the (medicinally) valuable paraldehyde, a clear, colourless liquid of ethereal smell, which freezes on cooling and melts at 10.5° . B. P. 124° , S. G. 0.998. Readily soluble in alcohol and ether, less so in water (particularly in warm water).

Paraldehyde:

C. Erdmann, Leipzig-Lindenau.

Paranephrine. A substance prepared from the suprarenal glands which increases the blood pressure. It is obtained from the gland without the aid of acids and alkalies. Sold in sterilized solution 1 : 1000. It is used to stop bleeding; internally for bleeding of the stomach and intestines, and to stop bleeding in operations, gynaecology, &c.

Paranitraniline see "NITRANILINE".

Paraphenylenediamine, see "PHENYLENEDIAMINE".

Parchment paper. (Papyrine, vegetable parchment.) If paper is treated by a certain process with strong sulphuric acid a starch-like body, amyloid, is produced, and on this principle rests the manufacture of parchment paper. 1 kg of concentrated sulphuric acid is diluted with 125 g of H_2O . Clean, unsized paper is dipped into the solution for 3—12 seconds (according to the thickness) and then washed well to free it from all traces of the acid. A gelatinous coating is formed by this treatment which renders the paper transparent, waterproof and tough. Ammoniacal copper oxide or zinc chloride solution can also be used instead of the above named substance for making the solution. The parchment paper which is also sometimes oiled with paraffin, is then passed through a calander (polished hot rollers), to increase the smoothness. It is used for packing, binding books and many such purposes in place of real parchment, and it is employed for diaphragms for osmotic and electrolytic purposes. Coloured parchment, prepared in a particular way serves as a substitute for leather.

Paris blue see "IRON COLOURS".

Paris lake see "COCHINEAL".

Paris red see "LEAD COLOURS".

Parodyne see "ANTIPYRINE".

Pastel colours. The crayons or chalks for pastel painting have to be made in all possible tones and shades as the colours cannot be mixed except in very rare cases. The colours are made of many different kinds of pigment, with kaolin, gypsum glue, gum Arabic, &c. As a rule the pastel colours are pressed into crayons, but they can be procured in the form of powder and also as a paste.

According to Germ. Pat. 148214, crayons are made by damping the colouring matter, graphite, eosine, &c. with a fluid, which is soluble in water but does not dry, such as glycerine. The resinous adhesive, colophony, is then added; this obviates the injury to the colour frequently caused by melting the resin with the pigment.

Pasteurization see "MILK" and "PRESERVING".

Patchouli, oil of. An essential oil obtained from *Pogostemon Patchouli* by distillation with water. It is a viscid brown oil, S. G. (at 15°) 0.97—0.99 which, on account of its powerful odour, is extensively used in perfumery.

Patent red see "MERCURY COLOURS".

Patent yellow see "LEAD COLOURS".

Patina see "METALS, COLOURING".

Pearl white see "BISMUTH COLOURS".

Peat. The most recently formed fossil fuel. It has been formed by the decay of plants, and the process is still proceeding.

Peat is obtained in various ways according to its nature. It is cut out by spades or machinery in the form of bricks and dried in the air. When it is too muddy or too earthy it is taken up in buckets, sieves or dredging machines and moulded after drying. In the latter case it is also frequently placed in moulds and dried. Machines are generally used which cut up the dredged

material and stir it (if necessary with water) to a uniform pulp which is spread out on drying grounds and then moulded after some time either by hand or machinery. Another method is to dry the natural peat in centrifugal machines, then to grind it and after another drying, to press it into shape by steam-heated presses.

To make peat a more uniform and valuable fuel it is dried in special peat kilns. It is also frequently converted into peat coal by heating to 250—400° C; in this form it is suitable for metallurgical purposes. This peat coal produces about 6500 heat units, i. e. the amount produced by a medium quality coal; the cost of production is said to be about 3 shillings per ton of peat coal.

Apart from its use as fuel, peat when crushed is used in agriculture as a manure and as litter, as a disinfectant, as an excellent non-conductor of heat, as a packing material, and in making porous bricks; peat paper and peat card board are also known. The peat of highland marshes in particular is used as litter after preliminary drying, raking, drying again and finally tearing by machinery into fibres of the length of a finger. The dust formed in this process is sifted off and mixed with 2 % H_2SO_4 for use as a strong disinfectant, &c.

Peat coal see "PEAT".

Peat gas see "WOOD GAS".

Pegamoid see "LEATHER SUBSTITUTES".

Pegu see "CATECHU".

Pengine. Obtained from a mixture of milk-sugar and pure rennet.

It is a fine white powder readily soluble in water and in milk. It causes the latter to coagulate readily. 1 litre milk may be coagulated in 2—3 minutes by the addition of 8—10 g pengine. The milk is first boiled and then cooled to 40° before the ferment is added. After curdling the milk is vigorously shaken until the curd has disappeared. Pengine is an excellent medium for this purpose and serves to make milk much more digestible for infants, children, and adults.

Peppermint, oil of. (*Oleum Menthae piperitae.*) An essential oil obtained by the distillation of the fresh leaves and flowers of *Mentha piperita*. The plants are mown like hay and then allowed to dry since the dried plant can be completely distilled in 30 to 40 minutes, while the fresh plants require from 1 to 2 hours.

Commercially three kinds are distinguished, viz. English, German, and American, the English or Mitcham oil being the best.

It is a clear colourless or pale yellow oil with a strong smell of peppermint and a burning taste, which afterwards leaves a sense of cold on the tongue. S. G. 0.895—0.926. The following constituents have been recognized:—menthene (40—80 %), limonene, menthol (20—55 %), and menthone. The menthol is the most important constituent. The latter forms colourless crystals M. P. 43°, B. P. 212° which have the odour and taste of peppermint.

Oil of peppermint is used in perfumery and in the manufacture of liqueurs. It is subject to adulteration.

Pepsine. A digestive ferment obtained from the mucous and rennet glands and the fresh mucous membrane of the stomachs of calves (more rarely of pigs) by extraction with very dilute hydrochloric acid or very dilute alcohol. The liquid is evaporated at a low temperature (below 45° C). The residue is

subjected to various processes of purification without however producing an absolutely pure pepsine.

Pepsin is an important pharmaceutical preparation as it is able to digest coagulated albumen in the presence of hydrochloric acid (PEPTONIZING).

According to French Pat. 355560 those preparations of pepsine which are rendered soluble by the action of HCl but which do not keep well, may be made more stable and readily soluble in water by mixing them with the hydrochlorides of certain basic compounds (e. g. certain amido-carboxylic acids). Such substances are:—the hydrochlorides of betaine, glycocoll, leucine, and alanine.

Peptones. Intermediate products formed during the digestion of proteids by pepsine in presence of hydrochloric acid. They are used as nutrients by patients suffering from dyspepsia but are now less used than formerly on account of their unpleasant bitter taste. They are generally prepared from meat or caseine by processes of which the details are not disclosed.

According to French Pat. 355805 the process of obtaining peptones from the fibroin of silk (by distillation with HCl *in vacuo* below 40°) is simplified and made cheaper by substituting H_2SO_4 or H_3PO_4 for the HCl. The excess of the former may be removed by means of a calcium or barium salt whereas the excess of HCl had to be removed by means of a silver salt.

Perborates. Salts of perboric acid. According to Engl. Pat. 26790 (1904) sodium peroxide, boric acid, and a suitable zinc or magnesium salt are allowed to react in aqueous solution. The most important perborate is sodium perborate $Na_2B_4O_8 + 10 H_2O$; for its preparation and use, see "SODIUM COMPOUNDS".

Perehlorates. Salts of perchloric acid $HClO_4$. The method of preparation almost exclusively used until recently will be found under potassium perchlorate in the article on "POTASSIUM COMPOUNDS". Recently electrolytical methods of producing perehlorates from chlorates have become very important. According to WINTELER's investigations (Zeitschr. f. Elektrochemie VII, 644) perehlorates may be readily obtained from chlorates but not from chlorides. The formation of perchlorate is favourably affected by the addition of bichromate and sodium chloride, adversely by addition of sodium hydroxide. The degree of concentration of the electrolyte appears to be of little importance, though the yield rises with the current density. The bath should not be too cold. The only metal suitable as electrodes appears to be platinum. The use of bichromates in the electrolytic production of chlorates and perehlorates is protected by Germ. Pat. 136678; see "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL". A number of other patents are described in the same article.

Pereresan. A disinfectant consisting of a mixture of cresols, water, and soap. It is a pale yellow liquid which dissolves in water to the extent of 5 % giving a clear solution. Stronger solutions are cloudy. It dissolves in alcohol in all proportions but is only partially soluble in petroleum ether and benzene.

In the form of a 1—2 % solution it is a valuable disinfectant.

Perfumery. The subject includes the whole manufacture of fragrant preparations, i. e. of perfumes (fragrant waters, essences, and tinctures), pomades, toilet soaps, hair oils, incense, &c.

The materials used are partly natural and partly artificial.

The natural perfumes are for the greater part derived from the vegetable kingdom; only musk, amber, and civet are of animal origin. The artificial perfumes are partly imitations of natural substances, partly preparations which are only pleasant on account of their smell, or their resemblance to the natural perfumes.

In the manufacture of artificial perfumes extraordinary progress and results have been recently made; see articles on "TERPENES" and "ESSENTIAL OILS".

The perfumes of plants can be only partially obtained by pressing, extraction and distillation; others are so easily decomposed that they can only with difficulty be obtained by special methods. The perfume is extracted by means of fat by one of two methods, the method of infusion (maceration), and enfleurage. In the method of infusion the blossoms are treated with slightly warmed fat (60—70°) or fatty oil, the flowers are removed after a few hours, and replaced by others until the fat is finally saturated with the perfume. In enfleurage the blossoms are spread out between thin layers of cold fat poured out on glass plates, and then daily replaced by fresh flowers; after about a month the fat is saturated with the perfume. Some perfumes, for instance jasmine, and tuberose, can be extracted in no other way, but for various other perfumes this process has been more and more displaced by the extraction method. As a result of the careful investigations of A. HESSE it has been proved that jasmine and tuberose blossoms do not contain already formed any large amount of perfume but that traces of it are being continually formed and emitted. In this case enfleurage alone is of use, for this process differs from all other processes for obtaining perfumes in that the flowers can keep on producing perfume which is continually absorbed by the fat.

In the extraction method the flowers are first treated with quite pure carbon disulphide or petroleum ether, then the extraction liquid after standing for 24—48 hours poured off over other fresh flowers. When finally the extraction liquid is saturated with the perfume after the process has been often repeated it is carefully evaporated on the waterbath. The residue is a fatty mass which is scarcely $\frac{1}{500}$ % of the amount of flowers taken; it contains, however, the total perfume and is then dissolved in alcohol. The flower essences obtained by one of these methods are known as *extraits* (*extraits d'odeur*), *esspris*, and *bouquets*. The extracts obtained by the extraction of flowers with olive oil are known under the name "*huiles antiques*". Solutions of volatile oils in spirits are known as essences.

The manufacture of perfumery essences of natural and artificial perfumes has reached a stage of high perfection in Germany.

For a long time so-called fixateurs have been used in perfumery, that is, substances by means of which the perfume is retained better and which prevent its rapid evaporation; thus for instance amber is a well known fixateur. According to Germ. Pat. 144002 benzyl salicylate possesses this fixing property; 1 part of the ester is added to about 1000 parts of the finished perfume.

Perfumes, artificial. These are described under special headings, e. g. MUSK, PIPERONAL, &c., &c.

Apparatus for manufacturing perfumes:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Synthetic Perfumes:

Oscar Wender & Co., Dresden, Germany.

Perhydrol. Pure hydrogen peroxide (q. v.).

Periodic system of the elements.

Group			I	II	III	IV	V
Highest salt-forming oxide ...			M ₂ O	MO	M ₂ O ₃	MO ₂ MH ₄	M ₂ O ₃ MH ₃
Hydrogen compound			—	—	—	—	—
Period 0	Series 0		H = 1	—	—	—	—
" 1	" 1		Li = 7.01	Be = 9.08	B = 10.9	C = 11.97	N = 14.01
" 2	" 2		Na = 23	Mg = 24.3	Al = 27.04	Si = 28.3	P = 30.96
" 3	" 3		K = 39.01	Ca = 39.91	Sc = 43.97	Ti = 48	V = 51.1
" 4	" 4		Cu = 63.18	Zn = 65.10	Ga = 69.9	Ge = 72.3	As = 74.9
" 5	" 5		Rb = 85.02	Sr = 87.3	Y = 88.9	Zr = 90.4	Nb = 93.7
" 6	" 6		Ag = 107.71	Cd = 111.7	In = 113.6	Sn = 118.1	Sb = 119.6
" 7	" 7		Cs = 132.7	Ba = 136.86	La = 138.5	Ce = 141.2	Di = 145
" 8	" 8		—	—	—	—	Er = 166
" 9	" 9		—	—	Yb = 172.6	—	Ta = 182
" 10	" 10		Au = 196.2	Hg = 200	Tl = 204	Pb = 206.4	Bi = 207.5
" 11	" 11		—	—	—	Th = 232	—

Group			VI	VII	VIII		
Highest salt-forming oxide ...			MO ₃ MH ₄	M ₂ O ₃ MH	MO ₃ —	—	—
Hydrogen compound			—	—	—	—	—
Period 0	Series 0		—	—	—	—	—
" 1	" 1		O = 15.96	F = 19.6	—	—	—
" 2	" 2		S = 31.98	Cl = 35.37	—	—	—
" 3	" 3		Co = 52.45	Mn = 54.8	Fe = 55.9	Co = 58.6	Ni = 58.6
" 4	" 4		Se = 78.87	Br = 79.76	—	—	—
" 5	" 5		M = 95.9	—	Ru = 103.5	Rh = 104	Pd = 106.35
" 6	" 6		Te = 126	I = 126.5	—	—	—
" 7	" 7		—	—	—	—	—
" 8	" 8		—	—	—	—	—
" 9	" 9		W = 183.6	—	Os = 191.12	Ir = 192.6	Pt = 194.34
" 10	" 10		—	—	—	—	—
" 11	" 11		U = 240	—	—	—	—

Permanent green see "CHROMIUM COLOURS".

Permanent white see "BARIUM COLOURS".

Permanganates. The salts of permanganic acid. They are described under the respective metallic compounds.

Germ. Pat. 145368 deals with a method for the preparation of the permanganates of the heavy metals, the earth metals and of the alkaline earths by electrolytical means with the simultaneous formation of alkalis, H, O or Cl. The mixture of the permanganate of an alkali metal with the oxygen or halogen compound of the corresponding metal is electrolyzed in the anode compartment of an apparatus provided with a diaphragm.

According to French Pat. 337629 any permanganate may be prepared from barium permanganate. The latter is obtained by passing air, free from CO₂, over a dry mixture of pyrolusite and an alkali heated to a red heat and precipitating the solution of the melt with baryta.

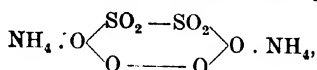
Permonite. An explosive consisting principally of ammonium nitrate, potassium perchlorate and trinitrotoluene. It was introduced into the potash mines with considerable success in 1905.

Pernambuco wood see "RED WOOD".

Peronine. Benzylmorphine hydrochloride. It is obtained according to Germ. Pat. 91813 by the action of benzyl chloride on morphine. The product of the reaction is washed first with water, then with a dilute solution of caustic soda and then recrystallized from alcohol. It is a loose white powder only soluble with difficulty. It is used as a substitute for morphine and codeine to alleviate the coughs of patients suffering from lung trouble.

Persio see "ORCHIL".

Persulphates. Salts of persulphuric acid, $\text{H}_2\text{S}_2\text{O}_8$. The acid is not known in a free state; the salts are obtained by electrolytical methods. The most important of these salts is ammonium persulphate



which is obtained by the electrolysis of a saturated solution of ammonium sulphate. The process is not difficult and is best carried out at a temperature of 7° with an E. M. F. of 5 volts. The persulphate separates as a solid, and the electrolyte must be neutralized after the removal of the persulphate before being further used; the substance employed for neutralizing is ammonium carbonate.

Sodium persulphate $\text{Na}_2\text{S}_2\text{O}_8$ is obtained according to Germ. Pat. 81404 by the electrolysis of Na_2SO_4 . The two electrodes are separated by a porous diaphragm; the formation of $\text{Na}_2\text{S}_2\text{O}_8$ takes place in the anode chamber, which contains sulphate and H_2SO_4 , the cathode chamber contains only H_2SO_4 . The electrolysis is carried out while the vessel is cooled and from time to time a little solid Na_2CO_3 is added to the contents of the anode chamber to neutralize the $\text{H}_2\text{S}_2\text{O}_8$ there formed. Potassium persulphate, $\text{K}_2\text{S}_2\text{O}_8$ is produced by the electrolysis of a saturated solution of potassium bisulphate. The current employed is 3 amp. and the process is carried out with cooling.

Another process for the manufacture of persulphates, or rather a special development of the usual method, is one in which use is made of a cell separated by a diaphragm and containing a platinum anode and a lead cathode. Alkali sulphate solution is placed in the anode and 50 % H_2SO_4 in the cathode chamber. The current strength is 50 amp. per 1 sq. m. The cathode liquid must now and then be strengthened with H_2SO_4 , and the persulphate must on formation be removed and replaced by sulphate.

Persulphates have recently been successfully obtained by the electrolysis of neutral sulphates without the use of a diaphragm, which is a considerable simplification of the ordinary process. The work can be carried out at a temperature of 30° , and is done with addition of chromate. On the whole it seems that carbon cathodes act most satisfactorily; the physical state of the platinum anodes does not seem to affect the yield to any great extent. This process is only suitable, however, for ammonium persulphate. Germ. Pat. 155805 deals with the addition of fluorine compounds in the electrolysis of sulphates; the yield when this substance is used is considerably increased. The addition of the fluorine compounds is a point of great importance in the preparation of potassium persulphate.

Ammonium persulphate is the only one of the persulphates manufactured on a large scale, the other salts are obtained from this compound. The persulphates which are of practical importance will be found described under the articles dealing with the metals in question.

Peru balsam. By this name are known various oily, resinous aromatic substances of which the San Salvador variety is the most important. This is obtained from the *Myroxylon Pereirae*. The tree is partially stripped of bark and the balsam caused to exude by lighting fires round the trunk.

Peru balsam is a dark-brown, syrupy liquid with a bitter taste and a strong odour of vanilla: S. G. 1.135—1.150. It quickly dries in the air. It consists chiefly of benzyl cinnamate and contains in addition resin, benzyl alcohol, cinnamic acid, stilbene, benzyl benzoate and some other aromatic substances, but no essential oil.

On account of its high price Peru balsam is liable to adulteration, it is frequently adulterated with fats, essential oils and sometimes with syrup. It is an official preparation and is also used as a substitute for vanilla in the manufacture of chocolate. It is further employed in perfumery.

Peruol. A 25 % solution of peruscabine in castor oil. It is prescribed for external use in itch, and, as a preventive against animal parasites as a colourless and odourless substitute for Peru balsam.

Peruscabine. Benzyl benzoate. $C_6H_5 \cdot CO_2 \cdot CH_2 \cdot C_6H_5$. The active constituent of Peru balsam which is now prepared synthetically. It is used in the same manner and for the same purpose as peruol (q. v.).

Petitgrain oil. This oil belongs to the series of orange oils and is obtained from the small unripe fruits, flowers, calyces and leaves of *Citrus Bigaradia*. S. G. 0.887—0.900. Amongst the aromatic constituents the following have been recognized:— bergamot oil, linalool and linalyl acetate.

Petroclastite see "SAFETY EXPLOSIVES".

Petroleum ether see "BENZINE".

Petroleum benzine see "BENZINE".

Petroleum (mineral oil, naphtha). The crude petroleum as obtained direct from the wells, is a yellow-brown to tar-black viscid fluid with a greenish fluorescence and a most disagreeable smell. Native oils with a pleasant smell are rarely found. Many kinds of petroleum quickly solidify after exposure to air, on account of the separation of the solids such as paraffin, asphalt, &c. Others again very rapidly lose their volatile constituents if means are not immediately taken to prevent this loss. The S. G. of crude petroleum varies as a rule between 0.98 and 0.94, although oils occur of lower (0.75) and of higher (0.97) density.

The petroleum oils consist principally of hydrocarbons. In some kinds, small quantities of compounds containing oxygen, nitrogen and sulphur occur. Crude petroleum can only be used for a few purposes. It is therefore usually distilled and separated into different fractions. These fractions, however, are not equivalent to definite, well-characterized chemical compounds, but are rather determined by practical considerations and experience. The distillation of crude petroleum is according to HOFER carried out as follows:—

Variety of oil	Boiling Point	Specific Gravity
I. EASILY VOLATILE OILS.		
1. Petroleum ether.....	40—70°	0.65—0.66
2. Gasoline.....	70—80°	0.64—0.667
3. C-Petroleum naphtha, Petroleum benzine, Safety oil.....	80—100°	0.667—0.707
4. B-Petroleum naphtha, Ligroine....	100—120°	0.707—0.772
5. A-Petroleum naphtha, Cleaning oil..	120—150°	0.772—0.773

Variety of oil		Boiling Point	Spec. fic Gravity
II. ILLUMINATING OILS. Petroleum and Kerosene.			
Illuminating oil	I	150—200°	0.753—0.864
"	II	200—250°	
"	III	250—300°	
III. RESIDUE.			
		over 300°	over 0.83
1. Heavy oils, a)	Lubricating oil	—	0.7446—0.8588
	b) Paraffin oil	—	0.8588—0.959
2. Coke .....	.....	—	—

The amounts of the separate fractions obtained from different crude petroleum are not always the same, but vary considerably, which fact naturally affects the value of the different products. According to Germ. Pat. 133426 the crude oil should be purified with HNO_3 before distillation in order to separate the sulphur, asphalt and resinous compounds. After the treatment with HNO_3 the acids and the newly formed acid nitro compounds are neutralized with 0.3—0.5 % lye and then removed by reduction with finely divided metals such as Zn, Al, &c.

The distillation of crude oil was formerly always carried out by a periodic system. At present, however, the distillation is performed, whenever possible, without interruption. The distillation is carried out in boilers of various types, the fuel used being as a rule the residue from previous distillations or inferior crude oils. Superheated steam is seldom used, and coal is never used except in cases where the crude oil is distilled away from the district of production. The gases are caught in pipes, tubes or box coolers, and in recently constructed stilleries in surface condensers where they are condensed. A special process for the continuous distillation of petroleum, for removing the more inflammable oils, is protected by Germ. Pat. 143078. According to a lecture given by AISINMANN of Campina at the V. International Congress for Applied Chemistry, Berlin 1903, the following 3 principal types of apparatus for the uninterrupted distillation of mineral oil are used. (Chem Zeitschr. II, p. 569.)

1. NOBEL'S SYSTEM and modifications of the same are characterized by the fact that the distillation is carried out in a series of boilers (1—15), which are joined together and connected with the feed reservoir of crude oil. With a constant level of liquid a constant fraction is obtained from each boiler in which the temperature is also constant. This system wastes no heat and is a rapid and productive method of working up the raw material. Preliminary heating of the raw oil before distillation is also now carried out by a heating apparatus, which works continuously and uses up much of the heat from the residues which was formerly wasted. This system is, however, only suitable for large works, since the equipment is rather expensive and considerable quantities of oil are necessary to make the process continuous.

2. SCHUCHOW'S SYSTEM AND MODIFICATION. This system is suitable for medium sized refining works with sufficient space and equipment. The system is characterized by the fact that only one boiler with a column is made use of for continuous distillation. The hot gases rise from the boiler through the column thus heating (on the principle of counter currents), the continuous flow of crude oil entering at the top. The oil reaches a certain temperature in the different divisions of the column and thereby loses certain fractions. Further fractionation, however, is more complicated and needs special apparatus.

3. ROSSMAESSLER'S SYSTEM AND MODIFICATION is characterized by the continuous injection of the crude oil into a vessel heated to a certain temperature. This process is accompanied by considerable danger of sudden

explosion of gas, and in cases where the decomposition proceeds further the products will be inferior and require to be redistilled.

A large number of patents is taken out every year dealing with the subject of the petroleum distillation, but without offering anything essentially new in the method of procedure. It is therefore sufficient to quote here the numbers of a few of the most recent without going into details. The following deal with the fractional or continuous distillation of crude mineral oil. Germ. Pat. 151415, 153422, 154755 and 163385; the Engl. Pat. 7207 (1903); the Amer. Pat. 755760, 764138 and 768796 and the Belgian Pat. 176833 and 179662.

For the distillation of German petroleum, see Germ. Pat. 169952.

In the first distillation only two fractions are as a rule collected.

1. Crude benzine, S. G. 0.74—0.76; B. P. up to 150° C.
2. Kerosene (illuminating oil), S. G. 0.75—0.870. The rest of the material forms the residue from which most of the heat is derived for the preliminary heating of the next supply.

The crude benzine contains the products contained in the table I (above). It is fractionated by another distillation (dephlegmating). The substances obtained from this distillation are then used in the following ways:—

PETROLEUM ETHER. Solvent for resin, caoutchouc and oil; for pharmaceutical purposes and also for producing cold.

GASOLINE. An extracting agent for obtaining oil from seeds. Is used for removing fat and oil from wool, for carburetting coal-gas, for burning in specially constructed lamps (gasoline lamps), and for propelling motors.

LIGROIN (Naphtha, benzine, cleaning oil). The fractions of crude benzine which have a boiling point above 150° pass under these and other names. They are used in chemical cleaning works, in the manufacture of rubber, for extracting resin, and vaseline, for the purification of wax, for cleaning machinery, as substitutes for turpentine oil, for diluting oil colours and also for lighting in the so-called benzine or ligroine lamps.

The second fraction of the distillation of crude oil, which includes the oils used for lighting purposes proper, is subjected to chemical purification, by being first treated with concentrated sulphuric acid and then with soda lye. During the process of refining, compressed air is now usually injected, for it has been found that this greatly increases and hastens the effect. In this manner the product kerosene oil, the most valuable constituent of mineral oil, generally known under the name of petroleum, is obtained.

The residue after the separation of the contents with a boiling point under 300°, is further worked up in various ways into such products as lubricating oil and vaseline. For details compare „MINERAL OILS“ and „VASELINE“.

Numerous processes have been published dealing with the purification of mineral oils, and the separation of the sulphur compounds, in addition to various processes for rendering it colourless and without smell. According to Germ. Pat. 159028 mineral oils are dried by causing evaporation during a circulating process. In this way the H₂O is eliminated.

The Amer. Pat. 744720 gives a method for the separation of the sulphur contents. The petroleum is treated with a slightly acidified aqueous solution of FeSO₄, NaCl and CuSO₄, the petroleum being then stirred up by a current of air. According to Germ. Pat. 160717 metallic sodium is added to the mineral oil before distillation in order to separate the sulphur impurities. The Na not only combines with the sulphur but also works catalytically, and can be again used for further operations. A by-product in the manufacture of potassium ferrocyanide (by the old method) known as decolourizing powder, is used for rendering mineral oil colourless. This powder consists of 30—40 %

of animal charcoal, large quantities of silica and silicates and some iron oxide. By the more modern methods of preparing potassium ferrocyanide now in vogue the powder is no longer obtained: there is, however, no lack of this substance for the purification of petroleum, since several factories still adhere to the old system. See also, "IRON COMPOUNDS". The American decolourizing powder, magnesium hydrosilicate, also effects the same object but in a much less satisfactory manner.

Many inventors have attempted to render petroleum free from smell; according to Germ. Pat. 141298 small quantities of essential oils (oil of carraway, turpentine, &c.) in the presence of alkalis are mixed with the petroleum. Germ. Pat. 147163 recommends the use of ketones and aldehydes, especially formaldehyde, for the same purpose. The reaction is carried out at a raised temperature in presence of acids or alkalies, with the simultaneous introduction of steam into the oil. According to Germ. Pat. 153585 the crude oil is treated with lead acetate solution: the latter solution should be of the same density as the oil. It is then treated at 180° with superheated steam till at least 20% of the oil has passed over. The residue is a faintly-coloured oil without smell, and the distillate a clear odourless lamp or motor oil. Mention should further be made of the Engl. Pat. 10004 (1903) according to which the distilled petroleum can be rendered odourless by treating with solutions of permanganates, persulphates or of chromic acid at a low temperature.

Experiments have recently been made for the purpose of obtaining solid petroleum by similar methods to those employed in the manufacture of "solid" spirits of wine. Compare "SOLID SPIRITS". According to Amer. Pat. 641962 (Chem. Ztg. 1900, page 127) petroleum is solidified by mixing about 91 parts by weight with 7 parts of soap and 2 parts of stearine. The mixture is heated till the soap and stearine are melted and thoroughly mixed, when it is allowed to cool and harden. Petroleum is solidified by an addition of 4—10% of a hard sodium soap containing 500—600% of sodium silicate (Germ. Pat. 151594). The Engl. Pat. 7481 and 26366 (1903) also treat of the manufacture of similar kinds of petroleum soap. — In many cases the mixture is not allowed to become quite solid but is absorbed by gypsum, shavings or other materials.

The Russian Government has adopted the following nomenclature for petroleum products.

1. **CRUDE PETROLEUM.** When the flash-point is not above 70° C. If the flash-point is above 70°, the oil is classed under 20 below.

LIGHT DERIVATIVES: 2. Petroleum ether S. G. below 0.700 distils at 80° C. 3. Light benzine, S. G. 0.700—0.717 containing up to 5% of constituents distilling at a temperature above 100° C. 4. Heavy benzine, S. G. 0.717—0.730, distils at a temperature up to 100° C, contains less than 5% of substances which distil above 100° C. 5. Ligroin, S. G. 0.730—0.750. 6. Cleaning oil, S. G. 0.750—0.770.

LAMP OILS. 7. Meteor, S. G. 0.806—0.810, flashes at 28° C, or above (ABEL-PENSKI apparatus). 8. Testefas, S. G. 0.820—0.823, flashes at 38° C or above, colour 1—2. 9. Kerosene, S. G. 0.815—0.826, flashes at 28° C or above, colour 2, 5. 10. Astraline, S. G. 0.832—0.835, flashes at 40—45° C, colour 2, 5. 11. Pyronaphtha, S. G. 0.855—0.865, flashes at 98° C or above, coloured. 12. Gas oil, S. G. 0.865—0.885, flashes at 98° C. 13. Solar oil, light, S. G. 0.885—0.895, flashes at 138°.

LUBRICATING OILS. 14. Vaseline oil, S. G. 0.885—0.895, flashes at 130° C (ABEL-PENSKI apparatus). 15. Spindle lubricating oil, S. G. 0.895—0.900, flashes at 150—185° C, viscosity (ENGLER) at 50° C 2.4—2.9. 16. Machine lubricating oil, S. G. 0.905—0.910, flashes at 185—215° C, viscosity 6—7½.

solidifies at -10° . 17. Cylinder lubricating oil, S. G. 0.911—0.920, flashes at $210-245^{\circ}\text{C}$, viscosity 12.5, solidifies at 5°C . 18. Valvoline or viscosine, S. G. 0.925—0.935, flashes at $290-310^{\circ}\text{C}$, viscosity at 100°C 5. 19. Mazute for the manufacture of oils, S. G. 0.908—0.916, flashes at 160°C or above, viscosity at 50°C 6—10.

FUEL. 20. Mazute, collected from the surface of petroleum residue, S. G. 0.895—0.935 or above, flashes at 270°C or above (see "MAZUTE").

Petroleum distilling apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

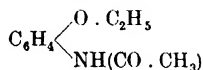
Pharmacy.

Pharmaceutical apparatus:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Phellandrene see "TERPENES".

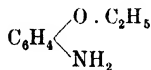
Phenacetine. Acetyl p-phenetidine.



Phenetidine (q. v.) is first prepared and this is then converted into the acetyl derivative by boiling with acetic acid.

A white, shining, odourless and almost tasteless powder, M. P. 135° , soluble with difficulty in water, readily in alcohol and freely in boiling alcohol. It is prescribed as an antipyretic and antineuralgic. Dose for adults: 0.5—0.75 g, every 3—4 hours; for children 0.5—0.2—0.5 g.

Phenetidine. p-amidophenetol.



In order to prepare it phenol is first nitrated and then the para compound separated from the ortho compound. The former is then converted into the ethyl derivative by the action of ethyl chloride. The ethyl derivative can then be reduced to the corresponding amido compound.

Phenocoll. Glycocoll-p-phenetidine; amidoacetyl-p-phenetidine. Chlor-acetylchloride is allowed to act upon phenetidine and the oxyethylmonochlor-acetanilide converted into phenocoll by the action of ammonia. In the form of its salts, phenocoll is used as an antipyretic, antineuralgic and antirheumatic.

Phenol. (Carbolic acid.) $\text{C}_6\text{H}_5 \cdot \text{OH}$.

It is still obtained from coal-tar and principally from the carbolic oil fraction, $210-250^{\circ}$. This fraction is treated with caustic alkalies in which the phenols dissolve. The alkaline solution is separated from the portion that is not attacked and then decomposed by the addition of mineral acids. Phenol is also obtained from the light oils which are for this purpose mixed with the carbolic oils. The amount of soda solution necessary is determined by a preliminary experiment: as a rule dilute solutions S. G. 1.09—1.095 are used. The oil and alkali are mixed either by mechanical stirring or by blowing in a thin stream of air.

The solution of sodium phenolate thus obtained is then freed from dissolved particles (e. g. naphthalene) by a current of steam and then decomposed with CO_2 or with H_2SO_4 . The use of CO_2 is more economical since furnace

gases may be used instead of the pure gas and Na_2CO_3 is obtained as a by-product.

The carbolic acid thus prepared is washed several times with water and is then sold as crude carbolic acid, generally after a further distillation in which the fraction between 175 and 210° is collected. The crude phenol (S. G. 1.045 to 1.065) contains about 40 % phenol in addition to cresols, &c. In order to purify it the crude acid is redistilled until the principal fraction (180 — 205°) solidifies on cooling to 8 — 10° . The mother liquor is either allowed to drain away or it is removed by centrifugal machines. The crystals must be again distilled if the product is required to remain colourless in the air.

The crystallized phenol thus obtained still contains cresols. In order to remove these the substance is treated with 12—15 % of water and cooled to -8° to -10° at which temperature a pure hydrate of phenol separates while the corresponding o-cresol remains liquid even at 20° ; m- and p-cresols form no hydrates. By means of centrifuges the crystalline matter is separated from the liquor and 90 % carbolic acid obtained by distillation. By repeating the process chemically pure phenol is obtained. The last distillation is carried out preferably *in vacuo* in earthenware apparatus.

The treatment given above (formation of hydrate and cooling) leaves as a residue a mixture of the three cresols. If steam distillation has been previously used this mixture is free from hydrocarbons and completely soluble in dilute as well as in concentrated soda lye. In case the tar oils have not been removed by steam distillation the product will still be soluble in concentrated soda lye but the hydrocarbons are thrown out of solution when the solution is diluted. This mixture containing no phenol is technically known as crude or "90 to 100 %", "95 to 100 %" or "100 % crude carbolic acid". (In England it is usually known as "cresylic acid".) Formerly the same name was used for the mixture of all the tar phenols, and even now "crude carbolic acid" is the term used for the raw material employed in the manufacture of crystalline phenol.

The low grade carbolic acids, which are on the market are the coal-tar fraction collected at about 200° . The percentage numbers denote the amount soluble in dilute soda lye.

Germ. Pat. 147999 dealing with the separation of the phenols of coal-tar from the neutral oils should be mentioned here. Neutral Ca-salts of the phenols are obtained by the action of lime or basic calcium phenolates on the phenols in presence of H_2O at a temperature below 70° . The solutions obtained are freed from the dissolved neutral oils &c. by distillation, preferably *in vacuo*, at a temperature at which the salts are not decomposed (about 60°C). After this treatment the liquors are decomposed into phenols and basic calcium phenates by further distillation *in vacuo* at 100°C or by distillation under normal pressure. The purified solutions may be also decomposed by mineral acids.

The synthetic production of carbolic acid is rapidly gaining in importance, since by this method it is obtained in a much higher state of purity than is possible when prepared from coal-tar. The low prices of benzene have rendered possible a synthetic production of carbolic acid. The process falls naturally into two phases: 1. The preparation of benzene-sulphonic acid by the action of fuming H_2SO_4 on benzene: $\text{C}_6\text{H}_6 + \text{H}_2\text{SO}_4 = \text{C}_6\text{H}_5 \cdot \text{SO}_3\text{H} + \text{H}_2\text{O}$, and 2. the fusion of sodium benzene sulphonate with caustic soda giving sodium phenolate $\text{C}_6\text{H}_5 \cdot \text{SO}_3\text{Na} + 2 \text{NaOH} = \text{C}_6\text{H}_5\text{ONa} + \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$. Usually 200 kg of sodium benzene sulphonate are fused in an iron vessel with 100 kg sodium hydroxide; carbolic acid is readily separated from the sodium phenolate by acids. In the case of tar phenol the cresols, the last traces of which cannot be eliminated by any process, are very undesirable impurities in various industries, e. g. in the manufacture of picric acid and

salicylic acid. Synthetic carbolic acid is of course, on account of its purity, excellently suited for pharmaceutical purposes, except for the fact that, it is not in great favour with chemists as it is almost odourless, while the intense tar-like smell of cresol has come to be considered characteristic of carbolic acid. At present, it is true the synthetic production of carbolic acid is not a prominent industry on account of the low prices of the usual product.

Crude carbolic acid is a brown oil with a penetrating smell. Pure carbolic acid forms large, colourless, rhombic needles; M. P. 39—41°, B. P. 180—181°. Soluble in 15 parts H_2O , miscible with alcohol, ether, benzene, glycerine, fats, and essential oil. Carbolic acid is strongly antiseptic and when concentrated very corrosive and poisonous.

Carbolic acid is chiefly used as a disinfectant, but also in the preparation of salicylic acid, picric acid, azocolours, oxidized triphenylmethane colours, &c.

Carbolic acid:

Domeier & Co., 8 Harp Lane, London E.C.
Brotherton & Co. Ltd., City Chambers, Leeds.

Carbolic acid apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückonstr. 6b (see advts.).

Phenol derivatives see "BENZENE COMPOUNDS", "NITROPHENOLS", &c.

Phenoline. A disinfectant, identically the same as Lysol (q. v.). It is a cresol made soluble in water by saponification. It is preferred to pure carbolic acid by physicians as it is less caustic and more pleasant to use.

Phenolphthalein. Its constitution will be found under "PYRONINE DYE-STUFFS". It is used as an indicator (see "ALKALIMETRY"), also medicinally, and for denaturing purposes.

Phenyform. An antiseptic odourless powder prepared from phenol and formaldehyde. It has antiseptic and deodorizing properties and is used as a non-poisonous antiseptic dressing for wounds, &c.

Phenylene diamine. $C_6H_4(NH_2)_2$. The m- and p-compound are the most important commercially, chiefly for the manufacture of dyestuffs.

m-phenylene diamine is prepared by reducing m-dinitrobenzene or m-nitraniline by Fe and HCl. According to the Germ. Pat. 130742 it is obtained electrolytically from m-nitraniline in aqueous solution in presence of an alkali salt by using a copper cathode with or without the addition of copper dust. The supplementary Germ. Pat. 131404 provides for the use of cathodes of other metals; Etlés has shewn that an addition of copper dust is absolutely essential in order to obtain m-phenylene diamine. — The pure base is very unstable so that it is either used at once or converted into the hydrochloride. Fine needles soluble in water; M. P. 63° C; B. P. 287° C.

p-phenylene diamine. Obtained by reducing p-nitraniline or amido-azobenzene (dissolved in aniline) by means of H_2S . The free base is stable and is a commercial product.

Crystals soluble in water. The commercial article is dark-brown or black in colour; M. P. 147°; B. P. 267°. p-phenylene diamine is the active constituent of various hair dyes, though for this purpose it is unsuitable in consequence of its poisonous nature.

Phenylglycocoll carboxylic acid see "INDIGO DYESTUFFS".

Phenylpropionic acid. $C_6H_5C : C.CO_2H$. A 1—3 % solution of the sodium salt is recommended as an inhalant in cases of tuberculosis.

Phenylurethane see "EUPHORINE".

Phosgene. COCl_2 is obtained by passing a mixture of chlorine and CO in molecular proportions over animal charcoal. It is a liquid with a suffocating odour, S. G. 1.432 (at 0°); B. P. 8.2°; readily soluble in benzene and glacial acetic acid. It is decomposed slowly by cold, and rapidly by hot water with formation of CO_2 and HCl. It is used in the manufacture of dyestuffs.

Phosphates see under the respective metals.

Phosphates:

Willy Manger, Dresden, Germany.

Phosphor bronze see "BRONZE".

Phosphor steel see "IRON ALLOYS".

Phosphorus. P. A. W. 31.03. In nature phosphorus occurs almost entirely in the form of phosphates, especially as calcium phosphate $\text{Ca}_3(\text{PO}_4)_2$. Of the mineral phosphates the following may be mentioned: phosphorite $\text{Ca}_3(\text{PO}_4)_2$; apatite $3\text{Ca}_3(\text{PO}_4)_2 + \text{Ca}(\text{ClFe})_2$; vivianite $\text{Fe}_3(\text{PO}_4)_2 + 8\text{H}_2\text{O}$; wavellite $2\text{Al}_2(\text{PO}_4)_3 + \text{Al}_2(\text{OH})_6 + 9\text{H}_2\text{O}$. These mineral phosphates are not used for the manufacture of phosphorus, which is almost exclusively obtained from the calcium phosphate of bones. The bones are either burnt to remove the organic matter, or the glutinous substances are extracted by treating the bones in autoclaves with superheated steam. Finally, the calcium phosphate of the bones may be extracted with HCl and re-precipitated from this solution with milk of lime.

The impure calcium phosphate $\text{Ca}_3(\text{PO}_4)_2$ obtained by one of these methods (containing magnesium phosphate, calcium carbonate, and calcium fluoride) is only very incompletely reduced to P by heating with C; on this account it is first converted into monocalcium phosphate by treating it, in leaden vats tarred on the inside, with H_2SO_4 free from arsenic, after it has been previously stirred with hot water. The reaction, which is completed in 48 hours, can be expressed by the equation $\text{Ca}_3(\text{PO}_4)_2 + 2\text{H}_2\text{SO}_4 = \text{CaH}_4(\text{PO}_4)_2 + 2\text{CaSO}_4$. The resulting paste is treated with more H_2O and, after the CaSO_4 precipitate has settled, the clear monocalcium phosphate solution (S. G. 1.05–1.07) is run off. The liquor is then evaporated in leaden pans until the S. G. is 1.45, separated from the CaSO_4 which has been set free, and heated to dryness with 27% rough slack in boilers over the fire flame. The product is then heated in fire-proof clay retorts at first moderately, when the monocalcium phosphate is converted into calcium metaphosphate: $\text{CaH}_4(\text{PO}_4)_2 = \text{Ca}(\text{PO}_3)_2 + 2\text{H}_2\text{O}$. It is then heated to a bright red heat when the phosphate is reduced to phosphorus $3\text{Ca}(\text{PO}_3)_2 + 10\text{C} = \text{P}_4 + \text{Ca}_3(\text{PO}_4)_2 + 10\text{CO}$. If quartz sand be previously added to the mixture the whole of the phosphate is reduced. $2\text{Ca}(\text{PO}_3)_2 + 10\text{C} + 2\text{SiO}_2 = \text{P}_4 + 10\text{CO} + 2\text{CaSiO}_3$. The phosphorus vapours which distil over are collected under water in suitable earthenware receivers.

The crude phosphorus thus obtained contains many impurities; it is refined either by filtering the molten phosphorus through coarsely powdered bone charcoal, or by treating it with a chromic acid mixture. Of late years, however, the process of refining by distillation has become more common. The purified phosphorus is melted under water and then by means of an aspirator sucked into glass tubes which are dipped in cold water where it solidifies in the form of sticks.

Recently the preparation of phosphorus by the electric current has become more important. (To-day half of all the phosphorus manufactured is produced

electrolytically). Sodium phosphate or the natural calcium phosphate are used and these compounds (the latter frequently after treatment with H_2SO_4) after being mixed with charcoal and sand are placed in the electric furnace. The air of the furnace is first replaced by coal-gas and the electric arc is then formed; a vigorous reaction takes place and the phosphorus vapours distil over and are caught in suitable receivers under H_2O .

The phosphorus thus obtained is a colourless and transparent wax-like substance which becomes yellow in the light. S. G. 1.84. It is as soft as wax at ordinary temperature but when cold is brittle. M. P. 45°C ; B. P. 294° . It is volatile even at ordinary temperatures. Insoluble in H_2O , readily soluble in carbon disulphide, benzene, chloroform, and sulphur chloride. It is very poisonous, emits light (in the air) in a dark room and ignites at 75° , on account of the latter property and the readiness with which it oxidizes it must be kept under water.

If the ordinary phosphorus (also called yellow or crystalline phosphorus) be heated in closed iron vessels to 250 — 300° it is converted into the so-called red or amorphous phosphorus. This is a red or reddish-brown mass, not acted on by the air, insoluble in CS_2 and the other solvents for yellow phosphorus. It is tasteless and odourless, non-poisonous, is non-luminous in the dark, and only ignites at a temperature of 260° . If distilled in an indifferent gas it is converted into the crystalline phosphorus.

Great interest has been excited over the so-called bright red phosphorus recently discovered by SCHENCK. It is obtained in a finely divided state for the manufacture of matches. The bright red phosphorus is obtained by heating ordinary white phosphorus in boiling phosphorus tribromide. This modification of phosphorus is quite different from the red P obtained by the dry heating of the yellow P, and consists of a solid solution of approx. 30 parts PBr_3 in P. Bright red phosphorus is non-poisonous but still very readily enters into reaction; it is used principally for the preparation of such matches as strike on any surface. See "MATCHES".

Yellow phosphorus is used for the preparation of phosphor bronze, phosphoric acid, and other phosphorus compounds, as well as for the manufacture of coal-tar dyestuffs. For most of these purposes the red phosphorus is preferred where it can possibly be used. Large quantities of yellow phosphorus have been used for the manufacture of matches, but there is now a tendency to restrict its use for this purpose.

Phosphorus compounds. In this article only those compounds which are of technical importance are treated. Other phosphorus compounds will be found under separate headings.

1. **CALCIUM PHOSPHIDE.** Ca_2P_2 . This substance is obtained by heating lime in a crucible with a specially constructed cover. A pipe which is long enough to reach to the bottom of the crucible is let into the cover. The phosphorus is fed into the crucible while the crucible and iron pipe are red hot. Calcium phosphide mixed with calcium phosphate is formed $14\text{CaO} + 14\text{P} = 5\text{CaP}_2 + 2\text{Ca}_2\text{P}_2\text{O}_7$. Calcium phosphide, which can also be obtained by fusing $\text{Ca}_3(\text{PO}_4)_2$ with lime in electric furnaces, serves for the preparation of phosphoretted hydrogen.

2. PHOSPHORUS CHLORIDES.

a) **PHOSPHORUS TRICHLORIDE.** PCl_3 . Obtained by passing dry chlorine over amorphous phosphorus which is heated in a retort. A clear colourless very mobile liquid which fumes strongly in the air and causes tears. S. G. (at 0°) 1.612. Solidifies at -112° ; B. P. 76° . This substance is a good solvent for phosphorus and mixes with ether, benzene, chloroform and carbon disulphide. It is decomposed by H_2O . It is frequently employed as a reagent.

b) **PHOSPHORUS OXYCHLORIDE.** POCl_3 . Obtained by the distillation of 1 part of anhydrous oxalic acid and 2 parts of phosphorus pentachloride, or by treating PCl_3 with KClO_3 . Germ. Pat. 138392 protects a method for obtaining this substance by passing Cl over a heated mixture of carbon and a metaphosphate. Such a mixture is obtained for instance by the partial reduction of calcium phosphate with carbon as carried out in the ordinary process for the manufacture of phosphorus. POCl_3 is a clear very mobile liquid of the colour of water, which fumes in the air. S. G. at 0° of 1.712. It solidifies on cooling to a crystalline mass which melts again at -1.5° . B. P. 108° .

c) **PHOSPHORUS PENTACHLORIDE.** PCl_5 . Obtained by passing dry chlorine into a solution of P in CS_2 . PCl_3 is first formed and this is again converted into the crystalline PCl_5 . The crystals are white or pale yellow; they sublime without melting at 100° and melt under increased pressure at 148° . When treated with H_2O it decomposes with formation of POCl_3 , which on the addition of more H_2O passes into phosphoric acid. This property of reacting with hydroxyl groups renders PCl_5 very important as a reagent, especially in organic chemistry.

3. **PHOSPHORUS TRIBROMIDE.** PBr_3 . This substance is obtained by dissolving the theoretical quantity of P and Br, separately in CS_2 , mixing the two at a low temperature, then removing the solvent and finally rectifying the product, or Br may be very carefully dropped on to amorphous phosphorus; only the first drops will cause a flash. According to a preliminary notice by CHRISTOMANOS, Ber. d. Chem. Ges. 1904, 37, 2883, very pure phosphorus tribromide is obtained (yield 88 %) by the action of Br on common yellow P under a layer of benzene. PBr_3 is a clear mobile liquid. S. G. 2.925 (at 0°); B. P. 175° . It fumes strongly in the air and decomposes in presence of H_2O with evolution of heat.

4. **PHOSPHOR-COPPER**, see "COPPER ALLOYS".

5. **PHOSPHORIC ACID.**

a) **PHOSPHORUS PENTOXIDE.** P_2O_5 . Obtained by the rapid combustion of phosphorus in a current of dry air in iron cylinders. It forms a white, snow-like, loose powder, which absorbs moisture from the air with great avidity, forming metaphosphoric acid. $\text{P}_2\text{O}_5 + \text{H}_2\text{O} = 2 \text{HPO}_3$.

b) **PHOSPHORIC ACID** (ordinary phosphoric acid), orthophosphoric acid. H_3PO_4 is obtained by the decomposition of calcium phosphate with dilute H_2SO_4 in accordance with the equation $\text{Ca}_3(\text{PO}_4)_2 + 3 \text{H}_2\text{SO}_4 = 2 \text{H}_3\text{PO}_4 + 3 \text{CaSO}_4$. This acid is, however, very impure and can scarcely be obtained pure. When perfectly pure phosphoric acid is required it is obtained by the oxidation of phosphorus with HNO_3 , the reaction being much assisted by the addition of a small quantity of Br or (better) I. According to French Pat. 340272 phosphates are mixed with carbon and distilled *in vacuo* at a temperature not exceeding 800° , the vapours of various phosphoric acids pass over and can be caught in H_2O or alkali. The Engl. Pat. 2284 (1904) recommends heating natural aluminium phosphate to about 800° , no mention being made of carbon or a vacuum. The phosphoric acid vapours are removed by suction and absorbed by H_2O or alkali.

Pure orthophosphoric acid, when evaporated at a temperature of 180° , is a colourless syrup, from which large very hygroscopic crystals separate. On heating, the H_2O passes off, and at 200 – 300° the acid is converted into pyro-phosphoric acid $\text{H}_4\text{P}_2\text{O}_7$. At 400° it passes with further loss of H_2O into metaphosphoric acid HPO_3 . This acid solidifies to a colourless glass. Phosphoric acid is used for making phosphates and hydrogen peroxide.

5. **PHOSPHORUS SULPHIDES.** If amorphous phosphorus is fused with sulphur in any proportion, compounds such as phosphorus sulphide, phosphorus sesquisulphide and phosphorus trisulphide are obtained. Large quantities

of phosphorus sesquisulphide are made by mixing red phosphorus with a slight excess of sulphur and heating slowly to 330° in an atmosphere of CO_2 . Phosphorus sesquisulphide is used for making the so-called non-phosphorous matches which ignite on any surface. Compare "MATCHES".

6. PHOSPHOR-TIN, see TIN ALLOYS.

Photogene, see "SOLAR OIL".

Photography. The value of illustrations as a help to the understanding of the written text has greatly increased, most particularly perhaps in scientific and technological subjects. Many things can be properly explained only by the help of illustrations, e.g. in text-books, catalogues, prospectuses, &c. Such illustrations are, however, not as a rule as valuable as they might be if the expert, the inventor and the maker were all consulted by the artist. Too often the work is carried out by an artist who attempts to make too artistic a picture, or the result of the photograph is not sufficiently good, so that either the maker has to be content with an inaccurate illustration or he has to have another photograph taken. Further it is not always convenient to introduce a photographer into works, laboratories, &c. where processes are kept secret.

For these reasons it seems advisable that all people concerned should be able to reproduce illustrations, since in this way the number of illustrations would rapidly increase. Moreover their accuracy would do much to make them more generally useful.

Every well-equipped laboratory, factory, &c. should be provided with a photographic outfit for the purpose of preparing illustrations of apparatus, &c. The subject is of special importance in machine and instrument works where the proper illustration of the articles manufactured is an essential.

A proper choice of equipment is absolutely necessary for success. The author has paid particular attention to this subject and has arrived at the following conclusions.

The apparatus must be adequate to meet all requirements but need not be so expensive as that employed in reproducing works.

A good travelling camera, square in shape, is very suitable for the purpose. A fixed studio camera is not well adapted for this kind of work, as it is not easily moved from place to place. The most convenient size is 13×18 cm. If the lens is a good one and sharp negatives are obtained, enlargements can be readily prepared. The camera should be so constructed that it may be extended to double or even three times its length in order that small objects such as crystals, woven fabrics, &c. may be photographed on a large scale. The apparatus must not be too light since the object in view is the preparation of thoroughly good illustrations. The stand must be strong and rigid and made in two or three parts. The metallic fittings should be of nickel or at least be nickel-plated. Brass should not be employed, since even a short exposure to the action of acid fumes will seriously affect the parts. Such a camera with the stand costs from £ 5—10.

The most important feature is the lens. To buy a poor lens is very false economy, since it is impossible to obtain good sharp results unless the lens be of the best type. One lens is scarcely sufficient and a series of lenses is recommended. It is, however, not advisable for the amateur to work with many lenses, as the continual screwing on and off wears out the screw and also disturbs the construction of the lens. With care, however, a series of lenses may be employed with advantage and better work obtained. The object may be taken in various sizes from the same position, the diaphragm being chosen to suit the particular case. In this way beautifully sharp negatives can be obtained.

An instantaneous shutter is not absolutely essential as time exposures are generally given. For some purposes, however, instantaneous photographs are necessary, e. g. for observing the actions of explosives, for machinery in motion, &c. For time exposures a pneumatic shutter is most convenient.

In order to obtain the tones in their proper proportions orthochromatic plates should always be used. A yellow screen is often useful. Three of these should be kept of different depths of colour. For taking photographs of glass apparatus, machinery with bright metallic parts, &c. orthochromatic anti-halation plates should be used. The addition of acetone sulphite to the developer is also recommended for decreasing the amount of halation and the prevention of "fogging" (see "PHOTOGRAPHIC CHEMICALS").

Whenever possible daylight exposures should be made. In some cases, as for example, when the room in which the photograph is taken is subject to vibration, or when the object is in motion, magnesium light may have to be used. In such cases halation is very liable to occur, and the use of anti-halation plates and the addition of acetone sulphite to the developer are almost essential. The same applies when the photograph is taken by means of the arc-light, particularly if the arc itself comes into the photograph.

It is immaterial by what process the photograph is reproduced. It is always best to send the negative and not the positive to the reproducer as he can then proceed in the manner best adapted to the matter in hand.

The author believes that too little attention is paid to the reproduction of stereoscopic photographs, and that in the future such illustrations will be of the greatest value for catalogues, &c.

Photographic chemicals. Only the most important are here discussed.

I. DEVELOPERS.

1. ADUROL. A bromine substitution product of hydroquinone, the preparation of which is protected by Germ. Pat. 111798. As far as its developing properties go it comes between hydroquinone and the true rapid developers. Adurol may be used to make concentrated, ready-mixed, stock solutions (which keep for some time) without the use of caustic alkalis. As this ready mixed developer does not turn brown by oxidation in the air it may be used repeatedly. Stock solution A: 10 g adurol, 80 g cryst. sodium sulphite, 500 ccm H_2O ; B: 60 g potassium carbonate, 500 ccm H_2O . For time exposures take one part A, one part B, and one part H_2O .

2. AMIDOL (1 : 2 : 4 diamidophenol sulphate). Readily soluble in H_2O . In contrast with other organic developers it gives very active developing solutions with Na_2SO_3 without any additional alkali, i. e. it is used in neutral or slightly acid solution like the old iron oxalate developer. It acts rapidly and gives well graduated negatives. Stock solution: 200 g cryst. sodium sulphite are dissolved in 1000 ccm H_2O , and then 20 g amidol added; for use the solution is diluted with 3—4 parts water. If the developer is not used often it is better to keep only one solution, viz. 50 g cryst. sodium sulphite in 1000 ccm H_2O and to add 0.5 g amidol to 100 ccm of the sulphite solution immediately before use.

3. p-AMIDOPHENOL (rodinal). The active constituent of rodinal mentioned under No. 16. With alkaline carbonates it develops slowly and brings out details well, with caustic it acts very rapidly and gives strong contrasts. Stock solution A: 20 g p-amidophenol in 1 litre H_2O ; B: 120 g cryst. sodium sulphite, 120 g potassium carbonate in 2 litres H_2O ; for use, one part of A is mixed with two parts B.

4. PYROCATECHINE (Catechol; o-dioxybenzene). It develops more slowly but more intensely than hydroquinone. The following stock solution is recommended: A: 20 g cryst. sodium sulphite in 500 ccm H_2O with 10 g pyro-

catechins added afterwards; B: 100 g potassium carbonate in 500 ccm H_2O ; for use mix one part A, one part B, and one part H_2O .

5. EDINOL (p-amidosaligenin). A rapid developer which does not fog the plates, gives soft and very detailed negatives. Can be used for various exposures. The following is a good stock solution: 7.5 g acetone sulphite (see below), 5 g edinol, 30 g potash and 0.5 g potassium bromide are dissolved in the above order in 100 ccm H_2O . This solution diluted 100—300 times with H_2O is good for standard developing. The following edinol-hydroquinone developer is also recommended: 5 g acetone sulphite, 30 g cryst. sodium sulphite, 2 g edinol, 0.5 g potassium bromide, 1 g hydroquinone and 30 g potassium carbonate are dissolved in the above order in 150 ccm H_2O . This solution when concentrated is used to develop under-exposures, diluted to half strength for normal exposures diluted 4—6 times for plates of all kinds and diluted 6—10 times dilution for bromide papers.

6. EIKONOGON (sodium amido- β -naphthol- β -sulphonate). The negatives produced are very harmonious if the developer is used at a temperature of 20°C or a little below. Lower temperatures produce thin and flat negatives. The following solution is recommended: 120 g cryst. sodium sulphite, 50 g potassium carbonate and 30 g eikonogen are dissolved in 1 litre boiling H_2O and the warm solution poured into well stoppered bottles. This solution will keep indefinitely. If it acts too strongly, H_2O should be added, and the amount of K_2CO_3 should be halved when very soft negatives are required. As eikonogen itself works softly it is frequently combined with hydroquinone which gives harder results. A good hydroquinone-eikonogen developer is the following A: 100 g cryst. sodium sulphite, 16 g eikonogen, 4 g hydroquinone are dissolved in the above order in 900 ccm boiling H_2O ; B: 40 g K_2CO_3 in 200 ccm H_2O . For use mix 180 ccm A and 40 ccm B, adding 3 drops of potassium bromide solution (1 : 10).

7. IRON OXALATE. The acid iron oxalate developer has been to some extent forced out of the field by organic developers of alkaline character, though it is still much used. It consists of the following solutions: A: 300 g neutralized potassium oxalate in 1 litre distilled H_2O ; B: 100 g ferrous sulphate in 300 ccm distilled H_2O , adding 5 drops of pure H_2SO_4 . For use 3—4 parts of A are mixed with 1 part of B. By using other proportions this developer may be modified to an extent impossible in the case of other developers.

8. GLYCINE (p-oxyphenylglycocol). An excellent developer giving very clear and fine negatives with pure black tones. It develops very slowly, admitting of considerable differences of light and shade and is little subject to variations of temperature. Stock solution:—100 ccm H_2O , 25 g cryst. sodium sulphite; after dissolving this 5 g glycine are added, the whole stirred, 25 g K_2CO_3 added and the mixture shaken until all the ingredients have dissolved. For use the solution is diluted with 3—5 parts H_2O . Glycine is especially recommended as a developer that keeps well, the solution is then made as follows: 2 g glycine, 500—1000 ccm H_2O (free from air), 2 g cryst. sodium sulphite and 15 g K_2CO_3 . For normal or under exposed plates the smaller amount of water mentioned should be used; for over exposed the larger amount.

9. HYDROQUINONE (p-dioxybenzene). A developer much used by amateurs; it gives extremely strong, rather hard negatives of a bluish-black tone. The image appears comparatively slowly but then develops rapidly. Hydroquinone developer does not work well below 18°C . — Stock solution: 40 g cryst. sodium sulphite, 5 g hydroquinone and 65 g potash are dissolved in the above order in 150 ccm H_2O ; by placing the vessel in warm water solution takes place more rapidly. For use the hydroquinone solution (which keeps well) is diluted with 4—6 parts H_2O . As hydroquinone gives rather hard negatives, it is frequently combined with other developers; see 5. Edinol, 6. Eikonogen, and 11. Metol.

10. IMOGEN SULPHITE. This is no new developer, but a combination of several other developers with the requisite amount of sodium sulphite. Stock solution: A: 1 part imogen sulphite in 12 parts H_2O ; B: cold saturated Na_2CO_3 solution. For normally exposed plates 2 parts A are taken to 1 part B, for under exposures 2 parts A, 1 part B and 2 vol. H_2O , for over exposures developer that has been used is taken, or potassium bromide is added to fresh developer. The developing takes 4 minutes; the negatives show good detail.

11. METOL = Monomethyl-p-amido-m-cresolsulphate. This developer works exceedingly rapidly and energetically, the whole process taking from 2 to 3 minutes. Even when the development is protracted the negatives do not become hard. Stock solution: 15 g metol, 150 g cryst. sodium sulphite, 75 g K_2CO_3 and 2 g potassium bromide are dissolved in this order in 1 litre distilled H_2O . For use this solution is generally diluted with 3 parts of H_2O . Metolhydroquinone developer is much in favour; it consists of the following solutions: A: 400 ccm distilled H_2O , 2 g metol, 40 g cryst. sodium sulphite, 4 g sodium phosphate (Na_2HPO_4), 3.5 g hydroquinone and 2 ccm usual fixing soda solution (1 : 100); B: 400 ccm distilled H_2O , 40 g K_2CO_3 . For use equal parts of A and B are mixed.

12. ORTOL (compound of 2 molecules of methyl-o-amidophenol + 1 molecule of hydroquinone). It is used without alkali; fixing soda may be added which, curiously enough, does not blur the negatives but clears them. It works clearly and strongly, and keeps well. The following are the stock solutions: A: 1000 ccm cold H_2O , 7.5 g potassium meta-bisulphite, 15 g ortol; B: 1000 ccm H_2O , 120 g cryst. sodium carbonate, 180 g cryst. sodium sulphite, 1—2 g potassium bromide, 10 ccm fixing soda solution 1 : 20. For use equal parts of A and B are taken; when slower developing and softer negatives are required one part A is taken to one part B and 2 parts H_2O . In B the 120 g soda may be replaced by 60 g K_2CO_3 .

13. PARAMIDOPHENOL see "3. p-AMIDOPHENOL".

14. PINAKOL. P. A concentrated rapid developer which keeps well, containing pyrogallol (see No. 15) as the developing substance. Neither caustic nor alkaline carbonates are present; they are substituted by pinakol salt N (see below) and sodium sulphite. Developing with pinakol P is more rapid and the results are stronger and clearer than with the old pyro-developer; it also does not stain the fingers or the plates, and does not cause frilling. For use the solution is diluted with 8—10 times the amount of H_2O .

15. PYROGALLOL (1 : 2 : 3-trioxybenzol). "Pyro-developers" work rapidly and are capable of considerable variation. The drawbacks are that pyrogallol is poisonous and that the solutions stain the fingers and do not keep well. Stock solution A: 100 g cryst. sodium sulphite in 500 ccm distilled H_2O with 14 g pyrogallol and 6 drops H_2SO_4 ; B: 50 g cryst. soda in 500 ccm distilled H_2O . Both solutions will keep for some time in well stoppered bottles, especially if kept in the dark. For use 1 part A is mixed with 1 part B and 1 part H_2O . Beside this pyro-soda developer also pyro-potash developer is used, the stock solutions for the latter being as follows: A: 25 g cryst. sodium sulphite in 100 ccm distilled H_2O , adding 10 g pyrogallol and 3—4 drops (to slight acid reaction) of pure H_2SO_4 ; B: 45 g pure potassium carbonate and 12.5 g cryst. sodium sulphite in 100 ccm. For use 100 ccm H_2O are mixed with 3 ccm A and 3 ccm B.

16. RODINAL. Concentrated developing solution, the active constituent being the p-amidophenol mentioned under 3. The solution consists of 50 g cryst. sodium sulphite and 25 g K_2CO_3 in 1000 ccm distilled H_2O adding 5 g p-amidophenolhydrochloride. The solution is sold ready mixed; when concentrated it keeps for practically any time. It is used strongly diluted. When slightly diluted (1 : 10 to 1 : 20) it develops rapidly and produces great contrasts, when more dilute (1 : 30 to 1 : 40) very slowly and gives soft negatives.

17. UNAL. This is rodinal in the solid form, containing besides p-amidophenol the ingredients necessary for solidification. The corresponding amount of the preparation is dissolved in the prescribed quantity of H_2O .

ACETONE SULPHITE "BAYER" (Acetone bisulphite). An excellent substitute for sodium sulphite and potassium bi-sulphite in developing solutions. Acetone sulphite is also a suitable restrainer for rapid developers, so much so that by its aid plates greatly overexposed may be developed satisfactorily. Further it is a good preservative for developing solutions, a clearing agent for fixing baths and developing papers and finally for darkening the negative after the use of mercury intensifiers.

PINAKOL SALT N = 20 % solution of sodium amidoacetate. Pinakol salt N replaces alkali in organic developers without possessing the disagreeable property of the latter of affecting the skin of the operator and the gelatine film. Developing solutions made with pinakol salt surpass those made with soda and potash as regards rapidity, strength, and clearness.

II. FIXING, TONING AND COMBINED BATHS.

Neutral fixing solutions consisting of one part fixing soda (sodium thio-sulphate) in 4 parts H_2O are now rarely used; acid fixing solutions are invariably preferred as, besides keeping longer, they harden, the gelatine and clear the plates. Acid fixing solution is obtained by adding about 5 ccm acid sulphite solution (sodium bi-sulphite) to every 100 ccm. Another method is the following: A: 250 g cryst. sodium sulphite, 1000 ccm H_2O , 30 ccm conc. H_2SO_4 ; B: 250 g hypo, 1000 ccm H_2O . The acid fixing bath is then prepared by mixing 1000 ccm of B with 50—60 ccm of A. An acid fixing salt is also sold which gives an acid bath by dissolving in H_2O in proportions from 1 : 4 to 1 : 8.

In using TONING BATHS the paper prints are toned before fixing, while the combined baths effect both toning and fixing simultaneously. A good toning solution is obtained as follows: A: 4 g borax in 1000 ccm distilled H_2O ; B: 4.5 g fused sodium acetate in 1000 ccm distilled H_2O ; C: 1 g gold chloride in 50 ccm distilled H_2O . For use 100 ccm A, 100 ccm B, and 8—10 ccm C are mixed together.

ACID TONING AND FIXING BATH: 250 g hypo., 25 g ammonium sulphocyanide, 10 g lead acetate, 5 g citric acid and 0.4 g gold chloride in 1000 ccm distilled H_2O .

NEUTRAL TONING AND FIXING BATH: 250 g hypo, 20 g lead acetate, 10 g calcium chloride and 0.4 g chloride of gold in 1000 ccm distilled H_2O .

The manufacturers frequently give receipts for toning and fixing the various papers. These prescriptions should be followed. There are also ready made acid and neutral combined baths on the market.

FIXING SALT DESTROYER. The fact that the last traces of hypo are very difficult to remove from the plates (and papers) while the durability depends so much on the removal of these traces has led to attempts to discover substances which will decompose the last traces rapidly. The first substance of the kind was potassium persulphate (anthion), while at present potassium percarbonate is recommended. 10 g are dissolved in 1 litre H_2O and the

III. INTENSIFYING AND REDUCING.

INTENSIFIERS. There are mercury and uranium intensifiers. The former are applied as follows: The well fixed and washed negatives are placed in a solution of 2 g mercuric chloride and 2 g potassium bromide in 100 ccm distilled H_2O . When the negative becomes grey or white it is taken from the liquid rinsed in H_2O for one minute and then placed in a solution of 10 g cryst. sodium sulphite in 80 ccm distilled H_2O until the whole gelatine film becomes black. Thorough washing must take place before drying. When uranium is used two solutions are prepared: A: 1 g uranium nitrate in 100 ccm distilled H_2O ; B: 1 g potassium ferricyanide in 100 ccm distilled H_2O . For use 50 ccm A, 10–12 ccm acetic acid, and 50 ccm B are mixed in this order.

REDUCERS. The ferricyanide reducer (FARMER'S reducer) consists of 100 ccm hypo solution 1 : 4, with 5–10 ccm of a 10 % solution of potassium ferricyanide. This reducer destroys the finer middle tones, i. e. increases the contrasts. — Ammonium per-sulphate reducers act on the darker parts of the plate, i. e. it diminishes the contrasts; a 3–5 % solution of ammonium persulphate is used. The plates are first reduced then slightly rinsed in H_2O , placed in a 10 % sodium sulphite solution and finally well washed. — A uniformly reducing agent is the cerium sulphate reducer consisting of 10 g cerium sulphate in 100 ccm H_2O and 4 ccm H_2SO_4 .

IV. FLASHLIGHT.

1. 30 parts potassium chlorate, 15 parts magnesia powder and 5 parts antimony sulphide are finely powdered and mixed dry. A mortar must not be used.

2. 3 parts finely powdered potassium permanganate are mixed with 2 parts magnesium powder. This receipt has proved reliable.

3. According to Germ. Pat. 136313 mixtures of very fine magnesium or aluminium powder with finely ground manganese peroxide are very suitable for flash-light preparations; these mixtures are not very explosive nor do they give off fumes smoke or poisonous gases. According to the same patent certain substances, e. g. $Sr(NO_3)_2$ reduce the rapidity of burning and produce a coloured flame.

4. According to Germ. Pat. 158215 smokeless and harmless flashlight mixtures burning very rapidly and giving an intense light are obtained by mixing magnesium- or aluminium-powder with nitrates of the rare earths (especially of thorium, cerium and zirconium). For instance a mixture of equal amounts of finely powdered thorium nitrate and finely granulated magnesium powder.

5. Engl. Pat. 27267 (1904) also deals with the addition of salts of the rare earths to flash light mixtures of Al or Mg. The metal powder should be mixed with alum or some other sulphate.

6. An excellent flash light powder, indifferent to friction or percussion is put on the market by FRIEDRICH BAYER & Co., Elberfeld. It appears to be made according to Germ. Pat. 136313 mentioned under 3., consisting of a mixture of magnesium and manganese peroxide. As the two ingredients are packed separately all danger in use or storing is avoided and the product is transmissible by post.

7. Panchromate flash light powder gives out orange rays in addition to the blue and violet rays which are emitted by the ordinary mixture.

8. Recently TIME LIGHTS have increased in importance. They do not flash but burn slowly. This is attained by adding oxides, carbonates or silicates of the alkaline earths. BAYER'S time lights, which have proved very satisfactory, burn off in 2–3 seconds developing relatively very little smoke.

9. The mixtures mentioned under 1—7 may under no circumstances be blown into the flame; for this purpose only pure Mg- or Al-powder may be employed.

V. COLOUR FILTERS.

The use of orthochromatic plates practically necessitates the use of yellow glass screens; and for colour photography screens of various kinds and colours are absolutely necessary.

The following is taken from the Agfa-manual of the Aktien-Ges. für Anilinfabrikation:

"Excellent yellow screens may be obtained by the use of certain yellow aniline dyestuffs, auramine O appearing to be the most suitable, as it absorbs no other rays but the blue and violet, allowing the red, green and yellow to pass freely.

A proper yellow screen can be obtained only by the use of clear glass with parallel planes, as otherwise prismatic effects will occur. This is especially noticeable with lenses of long focal length.

Collodion or gelatine can be used to hold the pigment: The latter is preferable as it is less easily injured and does not separate readily from the glass.

The preparation of yellow screens consists in covering glass plates — of a quality difficult to obtain — with a yellow solution of collodion or gelatine of a certain constitution. This operation, however, requires a surprising amount of practice.

When a yellow screen for use with a lens of not above 20 cm focal length is required, the following will prove a reliable and satisfactory method.

Dry plates of soline glass (diapositive plates are usually made of this material) are fixed (acid or neutral) in non-actinic light washed and dried. Then the plates are placed in a cold saturated solution of auramine O for 5 minutes with continual rocking. The gelatine becomes intensely yellow. In order that the yellow screens should dry clear, and so as to obtain the required tone, the plates are put into running water. The colour will gradually fade and when the shade required is obtained the plates are taken out and hung up to dry."

There are various prescriptions for making pigment filters; the following are those recommended by MEISTER LUCIUS & BRUENING. The filters produced are toned for orthochromatic and pinachromatic plates (see "PHOTOGRAPHIC PLATES"):

7 cm of the gelatine made according to the following prescription are poured over every 100 square cm of plate surface. The dry filters consist of two coloured plates taken together and fixed with Canada balsam.

a) LIGHT FILTERS FOR THE THREE-COLOUR-PROCESS.

1. Blue filter.

4 g crystal violet are dissolved in 100 ccm warm water, 5—6 drops of acetic acid being added; 100 ccm of 8 % gelatine solution are mixed with 6 ccm of the colour solution and the whole filtered.

2. Green filter.

3 g tartrazine + 6 g patent blue, or 9 g filter green I, are dissolved in 330 ccm hot water. 100 ccm of 8 % gelatine solution are mixed with 4—5 ccm of the colour solution and the whole filtered.

This filter will allow a little red from the extreme end of the spectrum to pass; if this red — though quite harmless — is also to be absorbed 2.5 g tartrazine, 6 g patent blue and 4 g naphthol green are dissolved in 400 ccm water. 100 ccm of 8 % gelatine solution are taken to 5 ccm colour solution.

3. Red filter.

5 g filter red I are dissolved in 200 ccm warm water. 100 ccm of 8 % gelatine solution is mixed with 4 ccm colour solution and the whole filtered. The times of exposure when orthochromatic plates are used are in the following proportion Blue : green : red approximately 1 : 3 : 6.

b) LIGHT FILTERS FOR THE ADDITIVE THREE-COLOUR-PRINTS (CHROMOSCOPE).

1. Blue filter.

3 g crystal violet and 1 g methylene blue, free from zinc chloride, are dissolved in 100 ccm warm water with the addition of 5—6 drops of acetic acid; 100 ccm of 8 % gelatine solution is mixed with 7—8 ccm of colour solution and the whole filtered.

2. Green filter.

6 g tartrazine and 1 g patent blue or 7 g filter green II are dissolved in 140 ccm warm water. 100 ccm 8 % gelatine solution are mixed with 7—8 ccm colour solution and the whole filtered.

If the extreme red is to be absorbed 6 g tartrazine, 1 g patent blue and 2 g naphthol green are dissolved in 180 ccm water; with 100 ccm 8 % gelatine solution. 8—9 ccm of the pigment is taken.

3. Red filter.

4 g tartrazine and 3.5 g rose bengale or 7.5 g filter red II are dissolved in 150 ccm water. 100 ccm of 8 % gelatine solution are mixed with 7—8 ccm colour solution and filtered. The times of exposure for orthochromatic plates are Blue : green : Red = 1 : 5 : 8 (nearly) and for pinachromatic plates about 1 : 4 : 3.

As all pigments are absolutely pure the filters dry uniformly and clear. The aqueous colour solutions will keep.

Photographic lenses see "PHOTOGRAPHY".

Photographic papers. Photographic papers may be classed as printing-out papers (p. o. p.) and those which have to be developed before fixing.

1. PRINTING-OUT PAPERS.

The most important p. o. p. method is still that involving the use of silver chloride. According to the underlying substance these are classified into three groups:

1. ALBUMEN PAPERS. The sensitive substance is silver chloride, the ground albumen.

2. SILVER CHLORIDE GELATINE PAPERS. The sensitive substance is silver chloride, the ground gelatine.

3. SILVER CHLORIDE COLLODION PAPERS. These papers, made in glossy and matt are especially high in favour.

Caseine is probably the ground substance used in BAYER'S (Elberfeld) Lactarine paper which gives very pleasing prints and resists high temperatures.

Of p. o. p. methods without silver salts the most important are direct printing platinum papers.

II. DEVELOPING PAPERS.

These are silver bromide papers, silver chlorobromide papers, platinum papers for developing, and pigment papers.

1. SILVER BROMIDE PAPERS. The sensitized part of these papers is exactly similar to that of plates, i. e. it is an emulsion of silver bromide and gelatine. These papers are therefore treated with the same care as regards the action of light as plates are. They are not only used for common printing but also for enlargements, a fact that is based on their great sensitiveness. All these

papers have a matt surface, and some of them a more or less coarsely granulated appearance.

2. **SILVER CHLOROBROMIDE PAPERS.** Silver bromide papers would be more used if their sensitiveness did not necessitate the discomfort of having to prepare and develop in the red light of the dark room. The attempts to combine the beauty of this printing process with the convenience of papers treated in shaded daylight have led to the manufacture of silver chlorobromide papers. Their sensitiveness is so far reduced that they can be put in the frames, &c., and developed at a little distance from gas- or oil-lamps, while they will print in ordinary daylight or artificial light.

3. **PLATINUM PAPERS** (for developing). These give still better pictures than p. o. p. platinum papers.

4. **PIGMENT PAPERS.** The pigment process, without doubt the most beautiful of all printing methods, is based on the fact that chromogelatin under the action of light loses its solubility in hot water. As any kind of pigment may be mixed with the chromogelatin all kinds of coloured papers are made, the prints being absolutely durable if the colouring matter is fast to light and air. The drawbacks to these advantages and the beauty of pigment prints are that the printing process can only be watched indirectly by means of the photometer, and that the print has as a rule to pass through two processes.

Photographic printing colours:

E. T. Gleitsmann, Dresden, Germany.

Photographic plates. Orthochromatic plates are dry plates of which the emulsion contains red, and sometimes also yellow and green pigments. These substances equalize the greater sensitiveness to blue and violet light rays peculiar to silver salts, so that the orthochromatic plates reproduce the true colour values better than ordinary ones.

The most important pigments used in manufacturing orthochromatic plates are erythrosin and cyanine, but these are now supplemented by many others, the best known of which are pinachrome and orthochrome, especially suitable for manufacturing panchromatic plates. Pinachromatic plates are also sold ready made.

The autochrome plates of LUMIERE have acquired considerable importance. They require only a single exposure and the process does not present the same difficulty as that of the LIPPMAHN method. The plates are prepared (Germ. Pat. 172851 and 182099) with a sensitive gelatine film and a "multi-colour filter" composed of red, green and blue starch grains. The method is simple and gives beautiful results. Only one copy can, however, be obtained. It is probable that a process of reproduction will soon be devised.

Photographic faking.

Carl Zeiss, Jena (Germany), complete apparatus of all kind, objectives etc.

Photometers.

Photometers:

Hans Heele, Berlin O. 27.

Phthalein see "PYRONINE DYESTUFFS".

Phthalic acid, o-benzene dicarboxylic acid. $C_6H_4(COOH)_2$. This acid is obtained by the oxidation of many benzene derivatives which contain 2 groups containing carbon in the O position. In practice it is usually made from naphthalene, e. g. by passing a strong current of chlorine into fused naphthalene and keeping the temperature below 170° . The naphthalene tetra-

chloride thus formed is oxidized with HNO_3 in shallow earthenware retorts with slightly curved tops, from which clay pipes lead to convey the acid fumes which arise. The crude solid phthalic acid is then washed, pressed, and recrystallized. The newest methods start directly from naphthalene. According to Germ. Pat. 79693 and 86914, naphthalene is oxidized with permanganates or manganates to phenylglyoxyl-o-carboxylic acid (phthalonic acid). The phthalonic acid passes readily by further oxidation into phthalic acid. Other methods make use of a chromic acid mixture for oxidation. The most promising of the newer methods of obtaining phthalic acid is probably that protected by Germ. Pat. 91202, in which naphthalene is oxidized to phthalic acid by means of sulphuric acid, mercury salts, which act as contact substances being added. The experiments of Ditz (Chem.-Ztg. 1905, 581) show that in these processes the mercury salts can be replaced with advantage by the oxides and salts of the rare earths. In practice a mixture obtained in the manufacture of thorium nitrate is used for this purpose.

A new method has quite lately attracted considerable attention which aims at the simultaneous production of phthalic and benzoic acids (Germ. Pat. 136410, 138790, 139956, 140999). It was found, that naphthols and the other substitution products of naphthalene such as nitronaphthalene, naphthylamine, naphthalene sulphonic acids, &c. are converted into a mixture of phthalic and benzoic acids by heating with fused alkalies or alkaline lyes and oxidizing metallic oxides, such as Fe_2O_3 , CuO , MnO_2 . The phthalic acid can then be separated from the benzoic acid by distillation. It is doubtful whether these processes can hold their own against the method of Germ. Pat. 91202.

According to Germ. Pat. 152063 naphthalene can be oxidized to naphthoquinone and phthalic acid without difficulty by electrolysis in acid solution in presence of compounds of cerium.

In a pure state phthalic acid forms colourless crystals M. P. 213° which dissolve readily in hot water, alcohol and ether, but with difficulty in cold H_2O .

The crystals are, however, seldom purified, but generally converted directly into the anhydride. By heating the crystals above their melting point the phthalic acid forms an internal anhydride of which the constitution is

$\text{C}_6\text{H}_4 \begin{array}{c} \diagup \text{CO} \diagdown \\ \diagdown \text{CO} \diagup \end{array} \text{O}$. This substance forms very long prismatic needles with a characteristic smell; M. P. 128°, B. P. 277°. The anhydride sublimes far below the boiling point and on being boiled in H_2O again passes into phthalic acid.

As a rule this acid is brought on to the market only in the form of phthalic anhydride, where it passes under the name of phthalic acid. It is used for making Pyronine dyestuffs (q. v.). Tetrachlorophthalic acid, $\text{C}_6\text{Cl}_4(\text{CO}_2\text{H})_2$, is also of considerable importance.

Test. If commercial phthalic acid, i. e. phthalic anhydride, forms colourless needles, evaporates completely, dissolves in benzene, and melts at 277°, it may be considered as sufficiently pure.

The quantitative determination is made by dissolving 1 g of phthalic acid or phthalic anhydride in 20 ccm of normal caustic soda solution and 20 ccm of water and then titrating with $\frac{N}{1}$ hydrochloric acid. One ccm of the alkali used for neutralization corresponds to 0.08303 g of phthalic acid, or 0.07402 phthalic anhydride.

Physostigmine (Eserine). $\text{C}_{15}\text{H}_{21}\text{N}_3\text{O}_2$. An alkaloid found in the Calabar bean (*Physostigma venenosum*). On account of the readiness with which the alkaloid decomposes, the preparation must be very carefully carried out.

The crushed beans are extracted with 85 % alcohol, the extract evaporated *in vacuo*, dried by NaHCO_3 and the alkaloid extracted by shaking with ether, and finally with dilute H_2SO_4 .

White, glistening leaves M. P. 102—103°. Sparingly soluble in water, readily in alcohol, ether, and chloroform.

It is very poisonous, and is used medicinally in the form of its salts. It is prescribed in cases of epilepsy and tetanus (internally or subcutaneously) in doses of 0.0005g to 0.001g once to three times a day. It is also used externally in 2 % solution for dropping into the eye on account of its property of contracting the pupil.

Phytine. The double calcium-magnesium salt of anhydrooxymethylene phosphoric acid. The acid is obtained (French Pat. 318311 and supplement) from vegetable substances such as oil cakes, roots, &c.

Phytine is a phosphorus compound containing 28 % P. It is readily assimilated and should prove of service as a strengthening agent.

Pickling (of metals). The action of various chemicals on metals removing the film of oxide from the surface. Especially important for electroplating as metallic films deposited by galvanic methods adhere only to metallic surfaces.

The preparation required for metallic articles in electroplating is a rough mechanical cleaning, removal of greasy substances and finally chemical treatment. This is not always the precise order of procedure and frequently one or the other is repeated. One thing, however, must be observed, that perfect pickling can only be effected after thorough cleaning and the removal of every trace of grease. The pickling itself is carried out with chemical solutions.

1. PICKLE FOR COPPER, BRASS, BRONZE, AND GERMAN SILVER.

Equal volumes of English sulphuric acid (66° Bé) and nitric acid (36° Bé). As nitric acid when sold is generally 40° Bé; 1 kg is diluted with 200 g water, the mixture is then 36° Bé and can be mixed with an equal volume of sulphuric acid. The action of this mixture can be increased by adding a little common salt at intervals. For fine articles of copper, bronze, &c. this pickle is too strong, a mixture of one part nitric acid to 10 parts water being used instead.

This as well as all other pickles may only be used cold; the acid mixtures, therefore, which become hot when the acids are mixed must be cooled before they are ready for use.

On the whole the pickling should last a few seconds only. The articles bound together and hung on a hook — small articles are with advantage placed on a sieve — are quickly dipped into the liquid, moved about for a second or two to remove air bubbles and lifted out again; the hands should not come in contact with the liquid. The articles are at once carefully rinsed several times in water so that the last trace of acid is removed.

2. PICKLE FOR IRON, STEEL, AND ZINC.

It is best not to pickle these metals at all (tin certainly under no circumstances). If the other three are, however, to be pickled a very dilute solution of sulphuric acid (1 part sulphuric + 100 parts water) must be used. After the process zinc is well rinsed, iron and steel rubbed with pumice-stone until they become uniformly grey.

Articles possessing very thin metal plating (especially gold-, nickel-, and brass-plated objects) are pickled to give the surfaces a suitable appearance. By a proper choice of the liquid a bright or matt surface can be produced.

3. PICKLE FOR BRIGHT SURFACE.
 - 2 kg English sulphuric acid (66° Bé).
 - 1.5 kg nitric acid (36° Bé).
 - 10 g common salt.
4. PICKLE FOR MATT SURFACE I.
 - 2 kg English sulphuric acid (66° Bé).
 - 3 kg nitric acid (36° Bé).
 - 15 g common salt.
 - 15 g zinc sulphate.
5. PICKLE FOR MATT SURFACE II.
 - 46 parts English sulphuric acid (66° Bé).
 - 46 parts nitric acid (36° Bé).
 - 4 parts zinc sulphate.
 - 3 parts sal ammoniac.
 - 1 part flowers of sulphur.

Picric acid. $C_6H_2 \cdot OH(NO_2)_3$, $OH : NO_2 : NO_2 : NO_2 = 1 : 2 : 4 : 6$, trinitrophenol. This acid is obtained by the nitration of phenol or from sodium phenol sulphonic acid. There are various processes extant of which the details are the trade secrets of the different firms. For instance, equal parts of purified phenol (crystals), M. P. 40° and conc. H_2SO_4 , S. G. 1.84 are warmed together by steam to 100°. Conc. HNO_3 is then added to the phenol sulphonic acid which has been formed and the whole well stirred. If the process is carried out in earthenware vessels without a stirring apparatus the HNO_3 is placed in the vessel and the phenol sulphonic acid, diluted with 2 parts H_2O , then added. In other factories the pure carboic acid contained in earthenware retorts is melted by indirect steam and the nitrifying acids, that is a mixture of HNO_3 with H_2SO_4 , in varying proportions. See "NITRATION". At the end of the reaction the crude picric acid separates on cooling as a solid crystalline mass. This is melted and poured into cold water, and thoroughly washed with cold H_2O to remove all H_2SO_4 . After this the crystals are removed, again melted and allowed to run through pipes into cold water when yellow crystalline leaves are formed. The water is again drained off the excess removed by centrifuging and the acid dried at 40–60°. If the acid is required quite pure it is converted into sodium picrate, $C_6H_2 \cdot ONa(NO_2)_3$ by treatment with Na_2CO_3 . This is recrystallized and then decomposed with H_2SO_4 or with $NaHSO_4$.

The method given in Germ. Pat. 125096 is as follows:—Aniline is used as the raw material for the preparation of picric acid, as the price does not vary so frequently as that of phenol. The aniline is first converted into sulphanilic acid which on treatment with nitrous acid gives diazobenzene sulphonic acid. This is readily converted into picric acid by gently warming with the theoretical quantity of nitric acid. The French Pat. 345441 describes a process for obtaining picric acid. 100 parts HNO_3 , S. G. 1.4 are mixed with 30 parts of denatured spirits, treated with 20 parts of crude phenol and the mixture vigorously stirred. When the nitration is finished the product of the reaction is poured into hot H_2O , and after cooling the picric acid present is separated in the usual way from the mother liquor. The yield is said to be good but the alcohol used is lost by oxidation. This is certainly a disadvantage not present in the usual methods.

Pure picric acid forms pale yellow crystalline scales having a bitter taste, which dissolve readily in alcohol and ether, less readily in hot, and with difficulty in cold water. M. P. 122.5°. If ignited it burns quietly but can be made to explode by the action of fulminating mercury in a closed space. The acid is poisonous.

Fused picric acid is used as a filling for shells and is known under the name of lyddite and melinite. It is an effective blasting explosive. Some of the salts of picric acid are important, forming as they do the principal material for a special kind of semi-smokeless powder, the so-called "PICRATE POWDER", see "GUNPOWDER". Picric acid is used for making powder and blasting materials, for dyes and for the manufacture of various organic compounds. See also "NITRO DYESTUFFS".

Picric acid:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin W. 9.

Pig iron, see "IRON". The ore is first roasted in the air to remove H_2O , CO_2 , S, As, &c., then broken up and mixed with different kinds of ore, according to the amount of iron contained, with the addition of slag-forming substances. The slag consists of silicate, for which reason quartz and clay, that is substances containing a large proportion of silicic acid and alumina, are used for iron ores rich in lime and magnesia; while on the other hand limestone or dolomite are added when the iron ore contains much SiO_2 and Al_2O_3 . The mixture of iron ores and added substances is then heated in blast furnaces over 30 m in height. The furnace is previously heated and the process is then carried on uninterruptedly. The ore is introduced from above (through the mouth) alternately with coke, anthracite, or charcoal. The furnace gases which escape at the top, which contain much CO , are caught by an apparatus hung over the top and employed for heating the blast. The lower part of the shaft narrows to the boshes where the molten slag and the liquid iron below accumulate. Air is conducted into the shaft from below, at a temperature of 500—800°. The hot gases as they rise dry the lowest part of the shaft and heat the charge, while in the upper parts the ore is reduced to metallic Fe. The Fe is at first plastic, but on absorbing more C readily passes into pig iron with a lower melting point (1000—1200°). The molten iron sinks and is protected by the layer of floating slag from further oxidation by the blast. The iron also absorbs more Si from the slag.

A lecture by GAYLAY on the subject of drying the blast with refrigerators has aroused much interest. The blast is dried by means of coolers and great advantages are thereby attained. The water is reduced from 13 to 4 g. GAYLAY thereby obtained an increase of 25 % and at the same time saved 20 % of fuel. Time will show whether this method will fulfil in practice all that it promises.

Pig iron is as a rule classed under the three following heads, according to the international agreement of Philadelphia.

1. GREY PIG IRON. Part of the carbon separates on cooling in the form of graphite. When broken, the fracture is grey. This is the form of iron worked up into cast iron.

2. WHITE PIG IRON. The carbon remains combined and the fracture is white. This iron is harder and more brittle than grey pig.

3. MANGANESE IRON (Ferromanganese). Carbon-iron-manganese alloys containing much Mn. The carbon remains combined. The colour of the fracture is white or yellowish. If light coloured parts show in grey pig, or grey grains in white, pig iron, the product is termed mottled pig, or mixed grey and white iron. If molten grey pig is quickly cooled it passes into white, and on the other hand if white pig is melted at a high temperature and slowly cooled it changes into grey.

Pig iron is brittle and not malleable. On being heated it suddenly melts. White pig, for BESSEMER's, MARTIN's and THOMAS's process, has a S. G. of 7.5—7.7, and a melting point of 1050—1100°. Grey pig, for casting purposes, has a S. G. of 7.0—7.3 and a M. P. of 1150—1250°.

For further details, see articles on IRON, INGOT IRON and MALLEABLE IRON.

Pill machines.**Pill machines:**

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Pilocarpine. $C_{11}H_{16}N_2O_2$. An alkaloid obtained from the leaves of the *Jaborandi* (*Folia jaborandi*; *Folia pilocarp*). The free base is a thick colourless syrup.

The salts of pilocarpine are used medicinally. It has a strong sudorific action and causes the secretion of saliva. It is also used in ophthalmic work. Max. dose 0.02 g to 0.04 g per diem.

Pinachromy see "PINATYPE".

Pinacol see "PHOTOGRAPHIC CHEMICALS".

Pinatype (Pinachromy). A method of coloured photography invented by Dr. KOENIG. Three negatives are taken, through a blue, green and red filter, respectively which are used to make diapositives. From these diapositives the printing plates previously made sensitive by chromate (gelatine plates) are printed; the printing is controlled by means of the photometer. The undecomposed chromium salt is washed off the exposed printing plate with water when the actual preparation of the coloured images begins:

The printing plate — well washed — corresponding to the red screen negative is placed in a specially prepared solution of a blue dye. Then a piece of transferring paper is pressed on to the plate and removed again after 15 minutes when the picture appears blue. The plate is replaced in the blue solution, and this process repeated so long as copies are required.

In the same way the plate corresponding to the green screen is immersed in a red solution and a blue "positive" pressed on to it. It is not very difficult to superpose the corresponding parts. When the paper is removed it bears the picture in two fundamental colours. The plate may be used any number of times in the same manner.

Finally the plate corresponding to the blue screen is treated in a yellow bath and the double coloured "positive" applied. When the paper is removed the photograph appears in natural colours. The third plate also may be used any number of times.

Pinatype pictures are very fast to light; to increase this and to harden the gelatine the prints are finally treated with a special fixing solution.

For the colour screens used in pinatype work, see "PHOTOGRAPHIC CHEMICALS".

Pinene see "TERPENES".

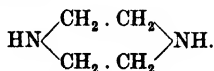
Pink salts see "TIN MORDANTS" and "TIN COMPOUNDS".

Pinoline see "RESIN OILS".

Pipe clay.**Pipe clay mordants:**

Willy Manger, Dresden, Germany.

Piperazine = Diethylenediamine.



It is obtained by the action of NH_3 on ethylene chloride.

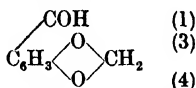
White crystalline substance M. P. 104° ; readily soluble in H_2O . It is prescribed in cases of gout, urinary calculi, &c., as it dissolves uric acid.

Dose 1.0—1.5 g, twice daily (in the morning and afternoon), each dose in a bottle of alkaline water (Apollinaris, seltzer, &c.).

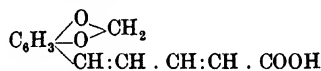
Piperine. $C_{17}H_{19}NO_3$. The alkaloid of pepper. Coarsely powdered white pepper is extracted with 90 % alcohol. After removal of the alcohol from the extract the residue is treated with dilute caustic soda solution. The crude piperine which is undissolved is washed with H_2O and recrystallized from hot alcohol after filtering through animal charcoal.

Colourless or pale yellow, shining crystals which have no odour, are insoluble in H_2O , sparingly soluble in cold, readily in hot alcohol.

Piperonal (Heliotropine). Methylene ether of protocatechnic aldehyde:



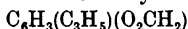
Formerly the starting point for the preparation was pepper. Coarsely ground pepper was extracted with alcohol and the extract after the evaporation of the alcohol was treated with KOH when the alkaloid piperine was left behind. On boiling with alcoholic KOH the piperine decomposes into piperidine and piperic acid; the latter has the constitution



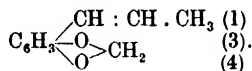
The K-salt of this acid is the starting point for preparation of piperonal.

It is oxidized with $KMnO_4$ and the mixture subjected to steam distillation, when the piperonal distils over. It can be obtained from this distillate by extraction with ether.

Heliotropine is now prepared exclusively from safrol



Safrol (q. v.) is the chief constituent of camphor oil from which it is obtained. By prolonged heating with alcoholic potash or sodium ethylate safrol can be converted into the isomeric isosafrol



— a liquid which has a smell resembling that of aniseed. 5 parts of isosafrol are treated with a solution of 25 parts $K_2Cr_2O_7$, 38 parts H_2SO_4 , and 80 parts H_2O at a temperature not above 60° . By this oxidation piperonal is formed. It is distilled with steam, and the distillate extracted with ether. After the evaporation of the ether crude piperonal is left. This is purified by shaking the ethereal solution with conc. $NaHSO_3$ solution.

Colourless glistening crystals with a strong and pleasant smell of heliotrope, M. P. 37° , B. P. 263° . Soluble in 500—600 parts of cold H_2O more readily in boiling H_2O , readily soluble in alcohol and ether. It is extensively used in perfumery.

Pitch. Two quite different kinds of substances are known under this name, the one being a product of wood-tar and the other of coal-tar. By heating wood-tar till all the volatile constituents have passed over the material known as common black pitch, is left as a dark, resinous substance, which can be kneaded and which becomes as hard as glass when cold.

This kind is used for caulking ships, for making water proof cements, cobblers' wax, &c.

Coal pitch is the material left in the still after the distillation of coal or anthracite. According as the distillation is interrupted earlier or later the product is soft or hard. Soft pitch is the more valuable of the two. Coal pitch is used in the manufacture of briquettes, and for making varnish, lacquer asphalt, &c. Brewer's pitch, a substance used for tarring beer barrels is made of pine resin or colophony melted with other materials which lower the melting point and increase the elasticity. The substances employed for this purpose are oil of resin, linseed oil, paraffin, ceresine, and the like. Aromatic pine resin was formerly much in demand for making brewer's pitch, but the materials are now required to be free from substances which have a low boiling point, are readily soluble and of an aromatic nature.

The residue from the distillation of colophony after the volatilization of the resin oils comes on the market under the name of smith's pitch. This material is also mixed with common black pitch for the manufacture of cobbler's wax.

According to Germ. Pat. 134109 and 137001 a substitute for pitch can be obtained by mixing peat, lignite, bituminous coal, wood, organic refuse, carbohydrates, glue, albumen (of various origin), fat and grease with tar, either together or singly and then subjecting to heat and pressure. The process is greatly facilitated by adding alkalies which cause the materials to run together. The volatile constituents are distilled off leaving in the still a substance which is a thick fluid when warm, but brittle and hard when cold.

According to Germ. Pat. 158731, pitch is made from tar and tar oils by gradually heating the raw material with sulphuric acid to 300°. The process takes about 1½—2 hours. Engl. Pat. 23680 (1904) also deals with the conversion of tar oils into pitch. Air or some other gas containing oxygen is blown into the heated oils, with the result that tar is first produced and finally after the volatilization of the volatile oils pitch remains as a residue.

According to Germ. Pat. 161236 the tar from water gas containing water is treated with some dehydrating agent such as caustic lime or burnt gypsum, stirred and allowed to stand and the completely dehydrated tar removed from below and then distilled. The pitch so obtained may be used for the ordinary purposes.

For the preparation of pitch from tar and tar oils see also Germ. Pat. 163446, Suppl. Pat. 171379 and 171380 and Germ. Pat. 170932.

Plantarine see "DRESSING MATERIALS".

Plasmon. A food preparation obtained by mixing moist caseine with bicarbonate of soda.

Plastic substances. According to Germ. Pat. 140522, substances can be made which keep soft and plastic for a considerable time and which, after hardening, can be worked up, carved, turned, &c. in the same way as wood. It is a well known fact, that the products of resinous condensation can be obtained by the alternating action of phenols and aldehydes at a high temperature in presence of acids. These substances, however, were found to be too brittle for use. According to the above-mentioned patent, the brittle, opaque substance formed by the condensation of phenol with formaldehyde is dissolved in a suitable solvent such as acetone, alcohol, glycerine, &c. It is then poured into moulds, dried and hardened; the substance becomes transparent, plastic, and elastic. The degree of hardness can be increased by dissolving in a mixture of formaldehyde and glycerine; the plasticity can be increased by adding camphor, caoutchouc, glycerine or the like to the substance.

According to Germ. Pat. 144162, plastic substances may be made from finely ground asbestos or mica by the use of aluminium sulphate and agar-agar

solution. Germ. Pat. 145251 protects a method for making plastic substances from peat and other fibrous materials, mechanically by pressing oil and resin into and through the mass, and then by oxidation converting the adhesive substance of the oil and resin into solids. According to Germ. Pat. 147994, plastic substances are made from caseine by treating the dried product before pressing, with very dilute acetic acid, instead of pure water to insure the desired degree of plasticity. Germ. Pat. 156536 treats of the production of plastic substances from the inner rind of *Adansonia digitata* (monkey's bread tree) by boiling the bast in alkali to form a thin paste, which is then poured into moulds, pressed and dried, when it forms a substance as hard as stone.

According to Germ. Pat. 158364 powdered slate is mixed with CaCl_2 , water glass and resinous soap, pressed into moulds, dried, and finally burnt.

Germ. Pat. 158496 and 159193 deal with a process for making a casting substance of plastic clay with caustic soda lye, ammonia, potash, waterglass, molasses, soap, &c.

The following patents also deal with the preparation of plastic substances:—Germ. Pat. 174877, 185240, 185241, 186388; French Pat. 368704 (from caseine); Germ. Pat. 187479 (from coagulated blood); Germ. Pat. 178645 (from peat); Germ. Pat. 179833 (from bones); Germ. Pat. 174123 and 186280 (from magnesium compounds). French Pat. 370490 recommends mixing fibrous substances with oils, fats, tar, &c., and treating the product in a special way. French Pat. 372584 deals of the preparation of plastic substances from leather, sawdust, cork, wool and cellulose.

See also the articles on "GALALITH", "CELLULOID", "WOOD, ARTIFICIAL", "STONES, ARTIFICIAL", "BRICKS", "STONE WARE", "PORCELAIN", "POTTERY" and "EARTHENWARE".

Plastrotyl see "TRINITROTOLUENE".

Plating. The union of two metals by rolling them together. The joint is made either with or without soldering. Plating is used wherever possible since it is cheaper than ELECTROPLATING (q. v.). In plating, metals of any thickness may be used, whereas in galvanoplasting the thickness of the deposit is usually limited. Sheet iron, for instance, is always nickel plated by rolling, while zinc can only be nickel plated by electrolytical processes. Tins, wires, and even complete articles are plated. Copper sheets are plated with silver, gold or platinum; iron sheets with copper, nickel or lead; lead sheets, zinc and tin-plates are always plated by rolling. Silver wire is plated with gold, copper, and German silver wire with silver, steel wire with copper or brass. The methods of plating vary very much according to the particular combination of metals. The details are usually trade secrets, so that no description can be here given. The same applies to electroplating, a process which is gaining in importance in the case of various metals. A. FISCHER has described reliable methods for electroplating aluminium (Chem.-Ztg. 1903, 987).

According to Germ. Pat. 139594 and 147378 metals are electroplated by forming an electric arc between them.

Plating metals:

Cannings. Great Hampton St., Birmingham.

Platinized asbestos. Loosely fibrous asbestos is moistened with a concentrated solution of PtCl_4 , dried, dipped for a moment into a solution of NH_4Cl , again dried and brought to red heat. The platinized asbestos so obtained contains 8 to 8.5 % Pt. The substance is soft and woolly and is employed for the manufacture of sulphuric anhydride. Platinized asbestos can also be

made containing as much as 25 % of this metal. Compare SULPHURIC ANHYDRIDE.

According to Germ. Pat. 134928, a platinum asbestos can be obtained, which although it contains only 2 % of platinum is still of practical value. A platinum salt is dissolved in methyl alcohol, ethyl alcohol, acetone or acetic ether, and the asbestos, pumice stone, &c. soaked in the solution and then ignited. The platinum salt is reduced in this way and the metal is found adhering to the material in a state of fine division.

Platinum. Pt. A. W. 194.8. Platinum is very seldom found in a pure state, but usually (and almost exclusively in the Urals) in the form of fine grains in alluvial sand beds. There are three qualities of platinum ore. No. 1 contains about 85 %, No. 2 about 82 % and No. 3 75 % of platinum. The other platinum metals are also present in the ore. Compare "PLATINUM METALS". The total amount of platinum obtained in the Urals amounts yearly to not more than 7000 kg, and its production necessitates the employment of 15 000 to 20 000 persons. The sand is first washed in sieve barrels or in tubs, and then on specially constructed wooden frames. Platinum ore is at present almost without exception treated by wet methods. There are several quite different methods of this kind, but they are all based on the principle of separation by chemical analysis.

As a rule the platinum ore is digested with *Aqua regia* diluted with 2 parts of H_2O . The action is greatly increased by carrying out the digestion under water pressure at 35—40 mm. Compare "AQUA REGIA". The filtered liquid is dried and the substance heated to 125° C, which reduces the chlorides of iridium and palladium to protochloride before affecting the platinum. If the residue is now mixed with H_2O , acidified with HCl and NH_4Cl added, pure platinum ammonium chloride $(NH_4)_2PtCl_6$, will be precipitated, while the chlorides of iridium and palladium will form double salts which readily dissolve. The iridium will only separate after evaporation of the mother liquor. Metallic platinum is separated from the final solution by iron filings; the undissolved iron being then extracted with HCl. The precipitated platinum is filtered off and again dissolved in *Aqua regia*. In this way the platinum metals are gradually separated from each other, while spongy platinum is obtained from the first precipitate of pure platinum ammonium chloride by bringing to red heat. The spongy platinum is then pressed together and melted in lime crucibles with an oxyhydrogen blow-pipe. Compare "OXYHYDROGEN GAS". The pure liquid platinum is usually cast in bars of 3—5 kg, and then hammered out by machinery into thick plates or wire.

Hammered platinum is a silvery or tin like metal which is very strong and flexible. It is softer than copper and is a relatively poor conductor of heat and electricity. Massive platinum has a specific gravity of 21.48 at 18°. If heated to white heat platinum becomes soft; and at a still higher temperature it can be welded. It melts at 17440 (NERNST and v. WARTENBERG). By heating platinum ammonium chloride a loose grey substance is obtained which is known as spongy platinum. Platinum black, which is still less compact than spongy platinum, is obtained by precipitating the metal with organic reducing agents or with zinc. Spongy platinum and platinum black possess the power of condensing extremely large quantities of gas, especially O.

A modification, soluble, or rather colloidal platinum has been obtained in a form to which the name of platinum hydrosol has been given. Platinum hydrosol is obtained when a solution of $PtCl_4$, 1 : 1500, is decomposed at the ordinary temperature with a few drops of very dilute hydrazine hydrate. The platinum solution so obtained is purified by dialysis and then forms a black or brown coloured fluid. If the alkaline salts of lysalbinic and

protalbinic acids are added to the hydrazine hydrate a more effective solvent is obtained. Compare "PROTALBINIC AND LYSALBINIC ACIDS". Germ. Pat. 157172 protects a method for preparing a very strong solution of colloidal platinum, palladium and osmium in a solid, stable form, soluble in water, by using hydrazine hydrate as a reducing agent in the way mentioned above, with the addition of the Na salts of lysalbinic or protalbinic acids. The largest quantity of platinum is used for making pans for the concentration of sulphuric acid and for other laboratory purposes, for making chemical utensils, for electric purposes, &c. It is also used for measuring rods, lightning conductor points, electrodes, &c. The "silver" for painting China is made from platinum; and very large quantities of platinum wire are used in dental practice. For many purposes alloys of platinum and iridium are preferred to pure platinum as being considerably harder. See "Platinum alloys".

Platinum:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Platinum alloys. These alloys are much used for various purposes. For instance an alloy of platinum and iridium containing 10 % of Ir is employed for measuring standards, &c. for which a considerable degree of hardness and resistance is required. Alloys of platinum with silver, or with silver and copper are used for making jewellery. Similar alloys containing nickel and cadmium, and sometimes also tungsten are used for making the works of chronometers. In the other alloys for the same purpose the platinum is with great advantage replaced, wholly or in part by palladium. Alloys of platinum with gold are used for making artificial teeth. Absolutely pure alloys of platinum with 40 % iridium and of platinum with 40 % rhodium are used for the electric measurement of high temperatures.

Platinum alloys:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Platinum bath see "PLATINUM PLATING".

Platinum compounds.

1. **PLATINUM BICHLORIDE** is formed by heating spongy platinum in dry chlorine gas to 250°. It is a greyish-green powder, insoluble in water, which dissolves in concentrated HCl and passes into Pt at a high temperature. There are also double addition salts of $PtCl_2$, which may be regarded as derived from chloroplatinic acid H_2PtCl_4 . Potassium platonic chloride, K_2PtCl_6 , is obtained by reducing K_2PtCl_6 with cuprous chloride. According to HERAEUS, K_2PtCl_6 is obtained by dissolving crystallized H_2PtCl_6 in twice its weight of H_2O , passing SO_2 into the hot solution until a sample no longer precipitates K_2PtCl_6 on the addition of KCl, and then adding a hot solution of KCl containing almost double the theoretical quantity of KCl. The K_2PtCl_6 which separates is removed, washed with alcohol and dried at the ordinary temperature in the absence of light.

Platinum Bichloride:

Johnson's, Cross St., Finsbury, London.

2. **PLATINUM TETRACHLORIDE.** $PtCl_4$. When Pt is dissolved in hot *Aqua regia* and the acid solution evaporated, the substance usually called platinum chloride is obtained. Chloroplatinic acid $H_2PtCl_6 + 6H_2O$ occurs as hygroscopic crystals. It is of considerable importance in analytical chemistry, since with K, NH_4 , Rb and Cs it gives a yellow crystalline precipitate, which is not readily soluble in water and is insoluble in alcohol. E. g. potassium chloroplatinate, K_2PtCl_6 .

3. **PLATINUM CYANIDE.** $\text{Pt}(\text{CN})_2$, is, like cyanoplatinic acid $\text{H}_2\text{Pt}(\text{CN})_4$, of little importance but the latter forms acid salts, the crystals of which exhibit fine dichroism. For instance potassium platino-cyanide $\text{K}_2\text{Pt}(\text{CN})_4$ forms yellow rhombic prisms with a blue reflex and barium platino-cyanide, $\text{BaPt}(\text{CN})_4$, forms monoclinic crystals, which are moss green, seen from the apex they look bright green while from the sides they are sulphur yellow with violet reflex. The barium salt and lithium rubidium platino-cyanide are used for painting ROENTGEN screens, which become fluorescent under the X-rays. BROCKET and PETIT (Zeitschr. f. Electrochem. 1904, 922) recommend the preparation of barium platino-cyanide from barium cyanide by means of an alternating current. The electrolytes are in this case $\text{Ba}(\text{OH})_2 + \text{HCN}$, the electrodes being plates of platinum. The current density should be 20 amp. at 5 volts.

Platinum compounds:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Platinum metals. In this class are included those metals which occur together with platinum in platinum ore, iridium, osmium, palladium, rhodium and ruthenium. A distinction is made between heavy and light platinum metals.

I. LIGHT PLATINUM METALS.

	Ruthenium	Rhodium	Palladium
Atomic weight	101.7	103	106.3
Sp. Gravity	12.26	12.1	11.8
Atomic volume	8.3	8.5	9.0

II. HEAVY PLATINUM METALS.

	Osmium	Iridium	Platinum
Atomic weight	190.8	193	194.8
Sp. Gravity	22.48	22.42	21.48
Atomic volume	8.4	8.6	9.0

All the platinum metals are very similar in properties, they all melt at a very high temperature, are difficult to oxidize, form salts which can be readily reduced, and their chlorides yield double chlorides with ammonium salts which are sparingly soluble. The separation of the different metals and the preparation of the same, can only be carried out by very complicated processes. Osmium and iridium are only found in platinum ore; they are usually combined as osmiridium and remain after treatment of the platinum with *Aqua regia*. Rhodium occurs in osmiridium, generally alloyed with gold; ruthenium is usually found with osmium.

See also the special articles on "IRIDIUM", "OSMIUM", &c.

Platinum metals:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Platinum paper see "PHOTOGRAPHIC PAPERS".

Platinum plating. Steel, copper, and brass may be plated with platinum by rubbing the articles with a paste of ammonium platinochloride and cream of tartar. A receipt for a highly brilliant platinum plating on copper, brass, and bronze is a boiling solution containing 1 part ammonium platinochloride and 8 parts ammonium chloride in 40 parts H_2O . The articles are "quickened", polished and then suspended in the solution for a few seconds; when taken out they are polished with precipitated chalk, washed and dried.

In galvanic platinum plating the solution used contains 10 g platinum chloride and 450 g sodium carbonate or 600 g sodium phosphate in 1 liter

distilled H_2O . The bath, which should be used hot, is most suitable for copper articles; the deposit is grey and has a matt surface; it should be polished with pumice stone or iron (not brass) polishing brushes. The anode is of platinum.

Podophylline. An alkaloid obtained from the root of *Podophyllum peltatum* which grows wild in America. It is used as an aperient and also as a specific against worms. In large doses it causes vomiting. Max. dose 0.1 g. Max. dose per diem 0.3 g.

Poison flour = Arsenious acid, see "ARSENIC COMPOUNDS".

Poisons, antidotes for.

1. ALKALIES see 6. CAUSTIC ALKALIES.
2. ARSENIC: The stomach pump, or give emetic, milk, white of egg, calcined magnesia, and the special preparation *Antidotum arsenici*. The latter must be freshly prepared, 100 g of officinal *Liq. ferri sulph. oxidat.* to be diluted with 250 g H_2O ; then stir in 15 g calcined magnesia with 250 ccm H_2O , mix the two together and give 2—4 desert spoons in warm water every quarter of an hour.
3. ATROPINE: Internally coffee and tannin. Cold douches and massage. Subcutaneous injections of pilocarpine or morphine by a physician.
4. CARBOLIC ACID: Milk, ice, calcium saccharosate, alcohol; stomach pump with 3 % sodium sulphate solution.
5. CARBON MONOXIDE: Fresh air, artificial respiration, massage, strong coffee, alcoholic beverages. Under certain circumstances the physician may inject common salt solution into the veins.
6. CAUSTIC ALKALIES: Vinegar and water, lemon juice, milk, and *Emulsio oleosa*; the latter to be obtained from the chemist. The patient should swallow lumps of ice.
7. CHLORALHYDRATE: Cold douches, artificial respiration, injections of strychnine and camphor by a physician.
8. CHLOROFORM: Fresh air, artificial respiration, inhalation of amyl-nitrate. — Electric shocks, injection of strychnine by a physician.
9. COCAINE: Strong coffee, inhalation of amyl nitrate; injection of camphor.
10. HEMLOCK: Stomach pump, emetics; artificial respiration, vinegar clysters, caffeine.
11. HYDROCYANIC ACID: Massage the body, artificial respiration, strong coffee, injection of ether and atropine.
12. LYSOL: The same as for carbolic acid.
13. MERCURY AND MERCURY COMPOUNDS: White of egg, milk, calcined magnesia, flour paste, iron powder, tincture of opium.
14. MORPHINE see 16. OPIUM PREPARATIONS.
15. NITRIC ACID see SULPHURIC ACID.
16. OPIUM PREPARATIONS: Stomach pump, strong coffee, alcoholic beverages, massage, artificial respiration. Injection of atropine.
17. OXALIC ACID: Lime water, calcium saccharosate calcined magnesia or chalk, and small lumps of ice (to be swallowed).
18. PHOSPHORUS: Stomach pump, give coffee, apply mustard plasters, rub with camphorated oil. Neither fat nor milk to be given.
19. SILVER NITRATE: Solution of common salt, milk, white of egg.
20. SNAKE BITE: Cauterize the wound with red hot iron; apply silver nitrate; wash with 1 % potassium permanganate solution; ligature above the bite. Alcohol to complete intoxication.
21. STRYCHNINE: Emetics. Tannin, chloralhydrate, cocaine. Electric battery (by the physician).

22. SULPHURIC ACID: Calcined magnesia, chalk, lime water, milk, flour paste, oatmeal, lumps of ice to be swallowed.

Poison wheat (*Fructus Frumenti venenatus*). Grain poisoned with arsenic and dyed with malachite green. It is used to destroy field mice. Grain treated with strychnine is also used in the same way. The bitter taste is concealed by the addition of saccharine.

Polarization.

CONSTANTS FOR OPTICALLY ACTIVE LIQUIDS.

- (α)_D = the specific rotation for the D line of the sodium spectrum.
 (α)_J = the specific rotation for the complementary colour of the middle yellow rays of the transmitted colour.
 t = temperature at which the observation was made.
 α = angle of rotation for a layer 10 cm in depth.
 c = concentration (grammes per 100 ccm of solution).
 p = percentage strength (grammes per 100 g of solution).
 d = S. G. of the solution.
 + = dextrorotatory.
 — = laevorotatory.

Unless otherwise specified the constants refer to the liquid substance or to an aqueous solution of the substance.

Substance	t	p	c	[α] _D	Observer
Cane sugar $C_{12}H_{22}O_{11}$	20	4—18	—	+ 66.810—0.015553 p	Tollens
d of solutions at 17.5°	20	18—69	—	—0.000052482 p ₂	"
(water at 4°)	20	5—18	—	+ 66.386+0.015035 p	"
	20	18—69	—	—0.0003986 p ₂	"
	20	18—69	—	+ 66.727—0.015534 p	"
d of solutions at 17.5°	20	18—69	—	+ 0.000052396 p ₂	"
(water at 17.5°)	20	18—69	—	+ 66.303+0.015016 p	"
	15	—	0—10	—0.0003981 p ₂	Hesse
	15	—	5	+ 68.65—0.828 c	
	15	—	10	+ 0.115415 c ₂	
	15	—	10	= 66.5	
	15	—	10	[α] j = 75.08 for [α] _D	
	15	—	10	+ 66.7 alcoholic sol.	Müntz
Cane sugar	—	—	—	+ 67	"
do. + 0.409 g	—	—	—	+ 64.9	"
= ¼ mol. CaO	—	—	—	+ 61.3	"
do. + 0.818 g	—	—	—	+ 46.9	"
= ½ mol. CaO	—	—	—	+ 51.8	"
do. + 1.637 g	—	—	—	+ 66	Hesse
= 1 mol. CaO	—	—	—	diminished by 0.170	Pollet
do. + 3.274 g	—	—	—	" " 0.140	"
= 2 mol. CaO	—	—	—	+ 54.54—0.557 c	Hesse
do. + 1 mol. Na ₂ O	15	—	5	+ 0.05475 c ₂	"
do. + 1 g KOH in	—	—	—	+ 47.925+0.015534 p	Tollens
100 ccm	—	—	—	+ 0.0003883 p ₂	"
do. + 1 g NaOH in	—	—	—	+ 52.718+0.017087 p	"
100 ccm	—	—	—	+ 0.0004271 p ₂	"
Milk sugar	15	—	2—12	+ 54.54—0.557 c	Hesse
$C_{12}H_{22}O_{11}$ + H ₂ O	20	8—91	—	+ 47.925+0.015534 p	Tollens
Glucose $C_6H_{12}O_6$	20	7—83	—	+ 0.0003883 p ₂	"
+ H ₂ O	20	7—83	—	+ 52.718+0.017087 p	"
Glucose $C_6H_{12}O_6$	15	—	2.8	51.78	Hesse
Grape sugar	15	—	3	51.67	"
$C_6H_{12}O_6$	15	—	3	51.67	"
Starch sugar $C_6H_{12}O_6$	15	—	3	51.67	"

Substance	t	p	c	$[\alpha]_D$	Observer
Fruit sugar $C_6H_{12}O_6$	14	—	—	$[\alpha]_j = -108$	Dubrunfaut
" "	52	—	—	" = -79.5	"
" "	90	—	—	" = -53	"
" "	14	—	—	" = -100	Neubauer
" "	—	—	12.8	$[\alpha]_j = -104$	Jodin
Invert sugar $C_6H_{12}O_6$	14	—	—	" = -26.65	Dubrunfaut
" "	52	—	—	" = -13.33	"
" "	90	—	—	" = 0	"
" "	0	—	17.21	$\begin{cases} -27.9; [\alpha]_D \\ = -(27.9-0.32 t) \end{cases}$	Tuchschmid
Mannite $C_6H_{12}O_6$	—	—	15	$[\alpha]_j = -0.03$	Pasteur
Quercite $C_6H_{12}O_6$	16	—	1-10	+ 24.3	Prunier
Active amylalcohol B. P. 127.5°	—	d=0.812 at 19°	—	— 1.8	Erlenmeyer]
Active amylalcohol B. P. 127°	—	—	—	— 5.6-5.7	Le Bel
Valeric acid B. P. 173° ...	—	d=0.933 at 19°	—	+ 3.6	Erlenmeyer
Amylchloride B. P. 97-99°	—	d=0.886 at 15°	—	+ 1.24	Le Bel
Amylbromide B. P. 117-120° ...	—	d=1.225 at 15°	—	+ 3.75	"
Amyliodide B. P. 144-145° ...	—	d=1.54 at 15°	—	+ 5.34-5.41	"
Dextrotartaric acid $C_4H_6O_6$	20	—	0.5-15	+ (15.06-0.131 c)	Landolt
Dextrotartaric acid	17	35.7	—	$[\alpha]_j = + 8.52$	Biot
Laevotartaric acid	17	35.7	—	$[\alpha]_j = - 8.53$	Pasteur
Malic acid	10	32.907	—	$[\alpha]_j = - 5$	"

Polarizing apparatus:

Hans Heele, Berlin O. 27.

Polishing or grinding materials see "GRINDING AND POLISHING MATERIALS".

Polishing or grinding materials:

Cannings, Great Hampton St., Birmingham.

Polonium see "RADIOACTIVE SUBSTANCES".

Polyprene see "CAOUTCHOUC".

Porcelain. Porcelain is one of the dense earthenwares; the name is more particularly applied to those with a white and transparent fracture. Three kinds are distinguished: 1. Genuine or hard porcelain (felspar porcelain), 2. soft porcelain, and 3. biscuit or figure porcelain.

1. Genuine porcelain is a white, hard, uniform mass with a fine-grained fracture. It is transparent in moderate thicknesses, cannot be scratched with a knife, and rings when struck. It is made by heating kaolin (China clay) with the so-called flux, which, itself infusible, melts with the China clay to a glass. The flux consists of felspar with the addition of gypsum, quartz, and chalk. The kaolin must be ground to a powder as fine as dust, or still better be first submitted to a process of levigation and in this way separated from the coarse grains. The washed clay is then mixed with the necessary amounts of felspar and quartz; the latter must also be ground very fine, a process always facilitated in the case of quartz and sometimes in the case of felspar by previously heating and cooling quickly. The wet, ground mass, or at any rate the wet mixture, is freed from water after settling; the rest is removed, by filter presses until a kneadable plastic mass is obtained. It is,

however allowed to remain a considerable time in moist cellars, where it becomes much more plastic owing to a kind of fermentation or putrefaction. After being kneaded once again the mass is finished; its composition varies between 40 and 66 % clay, 40 and 12 % quartz, and about 15–30 % felspar, sometimes also with a small addition (up to 6 %) of CaCO_3 .

The moulding of round and oval porcelain objects is carried out on the potters' wheel; others are made by hand, others again are cast or rolled.

In order to protect porcelain during the burning from the action of the fire and the flying ash, it is burnt in capsules or boxes of fire proof clay, which are suitably prepared for the separate articles. A distinction is made between "firing" porcelain and "burning" porcelain. In the first case the moulded and dried porcelain objects (alone or several together in fire clay capsules) are heated to the melting point of silver, the clay loses its chemically combined water and becomes hard. It is then glazed — the porcelain glazes consist of kaolin, felspar, sand, and marble (instead of the latter calcspar or chalk is sometimes used) in certain proportions. The glazing materials are weighed dry and then ground together in the wet state; the glazing is carried out either by dipping the "fired" objects in the cream-like glazing mass suspended in water, or by pouring the glazing mass over the objects; it is sometimes even sprayed on to the objects. The glazed objects are then brought into the capsules and burnt; the composition of the fire gases is of special importance in this process. Thus the felspar porcelain must be burnt with reducing gases at the beginning of red heat, and afterwards with neutral, or with a faintly oxidizing flame; in the first stage, before the pores have shut, that is before the mass fuses, the reducing gases must reduce the Fe_2O_3 compounds, which colour the kaolin yellow, so that the mass becomes white, while in the process of fusion the proper reduction must not be too strong so that the C contained in the mass does not ignite and give rise to bubbles. In the final burning the temperature must be brought to a white heat, when the porcelain just begins to soften. The porcelain furnaces may be classed into those arranged so that the process must be stopped at intervals, and such in which the process is continuous; most of the modern porcelain furnaces are heated with generator gas. The chamber furnaces consist of a row of chambers, in which one part is filled while the contents of another chamber are burning, the third cooling, and the rest are just being emptied, so that the process is rendered continuous.

2. Soft porcelain includes frit porcelain, bone porcelain, and the Seger porcelain: Frit porcelain has a composition similar to glass, it readily softens, and is a product which owes its milky transparency to devitrification. It is made by mixing 60 parts sand with 22 parts of melted saltpetre, 7 parts ordinary salt, 3.5 parts soda, 3.5 parts gypsum, and the same amount of anhydrous alum, fritting the mixture, powdering, washing in hot water, and making the real porcelain mass out of 75 parts frit, 17 parts chalk, and 8 parts of chalky marl. The mixture is made plastic with soft soap and glue, or with rubber, and used as a casting material; before glazing it is almost completely burnt, the objects being very carefully supported on account of the ready fusibility of the mass. The objects when burnt are no longer porous and a fused glaze containing lead is poured over them, and then burnt on at a lower temperature than before. This beautifully transparent frit porcelain, which is known as French soft porcelain, is on account of its great sensitiveness to differences of temperature gradually displaced by bone porcelain and the seger porcelain. Bone porcelain, which is also termed English soft porcelain or natural soft porcelain, consists of about 45 parts kaolin, 8 parts orthoclase, 9 parts quartz, and 44 parts bone ash. This soft porcelain is first completely burnt, then coated with a glaze containing lead and boron, and finally burnt to a finish at a lower temperature. The most important soft

porcelain is the Seger porcelain, which is an imitation of Japanese porcelain; it consists only of clay, quartz, and felspar, the flux being here present in larger quantity than the clay substance (aluminium silicate), while in hard porcelain the percentage of clay is larger than that of quartz and felspar together. Usually Seger porcelain is made from 25 % clay, 45 % quartz, and 30 % felspar. The mass can be readily moulded but must be dried very slowly as otherwise it contracts unevenly or cracks. The objects are fired just as for hard porcelain at the temperature of melting silver, then the glaze applied (by dipping or spraying), and finally completely burnt at a white heat. This process, which resembles that of the manufacture of hard porcelain, has the advantage that less fusible glazes can be used instead of the readily fusible but not very durable lead glazes of the frit and bone porcelain; the Seger porcelain glaze differs only from the hard porcelain glaze in the higher percentage of alkali and lower percentage of silica contained. According to a paper read by HEINECKE at the 5th International Congress for Applied Chemistry, Berlin, 1903, the author has succeeded in preparing a new soft porcelain by excluding felspar, introducing a specially constructed glass as a flux, and replacing the aluminium oxide of the felspar by a plastic clay substance. By this means porcelain masses are obtained which can be readily worked and are suitable for the most varied decorations. — A special advantage of the soft over the hard porcelain lies in the fact that a much larger variety of colours is at disposal; see "PORCELAIN COLOURS".

3. Biscuit porcelain is the name given to almost all unglazed porcelains, but when it is to be used for decorative purposes (e. g. figure porcelain) it is so constituted that the mass is fairly transparent. This end is attained by a high percentage of flux material. In other words it must be made like seger porcelain, or unglazed bone porcelain itself must be used.

Porcelain colours. Porcelain colours are coloured glasses which, finely ground, are brought on to the object with the brush, and then burnt in. For the ornamentation of hard porcelain the following are to be distinguished 1. sharp fire colours, which are so stable that they can be brought on under the glaze and can be burnt in together with the latter, and 2. muffle colours which are brought on to the glaze and burnt on at a much lower temperature (700—800°) in the muffle. Sharp fire colours which can stand the high temperature of the burning of hard porcelain without spoiling the colours are rather scarce. CoO is used for blue, Cr_2O_3 for green, Mn for yellow, Ni for brown and Fe for light grey-green. The muffle decoration consists either only in gilding, or in the use of the so-called fusible colours. In gilding finely divided gold mixed with bismuth subnitrate and HgO is brought on to the object and burnt in the muffle; the gilt only becomes lustrous after burnishing with agate and blood-stone. Of late years Dutch gold has been preferred. This immediately after burning appears as a lustrous layer (see "DUTCH GOLD"). In a similar manner Dutch platinum and Dutch silver are prepared. As a rule the colours used for the muffle decoration consist of a readily fusible lead borosilicate to which colouring metallic oxides are added. Thus black colours are obtained by adding IrO_2 , also by melting together Fe_2O_3 and Co_2O_3 , blue tones with Co (free from Fe_2O_3), lighter blue by the addition of ZnO to Co_2O_3 , green tones by means of Pr_2O_3 and CuO , yellow colours with Naples yellow (see "LEAD COLOURS"), PbCrO_4 and Uranium oxide, brick red colours with Fe_2O_3 , purple red with purple of Cassius (see "GOLD COLOURS"), coral red with chrome red (see "CHROMIUM COLOURS"). The finely ground fusible colours consisting of the metallic oxides mixed with the corresponding lead borosilicate are rubbed together with turpentine and thick oil (oxidized turpentine oil), brought on to the objects, and then burnt in muffles.

The small amount of heat which Seger porcelain requires for burning allows the use of a much greater number of colours under the glaze as well as between

two glazes. SEGER has given to his porcelain a particularly pleasing form of colouring by glazes, chiefly in the bright red peach colours to the dark crimson-red pink glazes (see "TIN COLOURS"), and the cherry red to the green-violet Cu_2O glazes of which the former are only formed in strongly oxidizing flames, while the latter are only formed by the strong reducing furnace gases. SEGER adapts his glaze colours to the composition of the colourless glaze by partly replacing its constituents by equivalent amounts of uniformly colouring oxides, thus for instance, a part of the CaO by CuO , NiO , &c., or on the other hand a part of the Al_2O_3 by Fe_2O_3 , Mn_2O_3 , Cr_2O_3 , U_2O_3 , &c. The colouring power of the separate oxides is very different and they are used in amounts varying from 0.5 to 10 %. Thus for blue CoO is used; for light green, CuO ; for dark green, Cr_2O_3 ; for yellow, U_2O_3 ; for dark yellow to brown, Fe_2O_3 ; for brown, Mn_2O_3 and NiO . The coloured glazes are burnt in with strongly reducing fire gases at the temperature of melting gold; the glaze layer is still porous so that any reduced parts are again oxidized by subsequent burning in excess of oxygen. On this account, above the temperature of melting gold an oxidizing atmosphere is employed; the burning is carried out almost exclusively in a furnace in which the flames are above.

The real painting of the Seger porcelain is usually carried out, as mentioned, under the glaze. The pure metallic oxides cannot be used as colours as they would otherwise dissolve in the glaze. They are on this account treated with sparingly soluble bases (for instance with Al_2O_3 , CaO , ZnO , or SnO_2), the mixture fritted, and the colouring body thus obtained treated with a small amount of boric acid to fix it to the objects.

Over the glaze, the Seger porcelain may be decorated with the so-called enamel colours, that is, with silicates of barium and borosilicates with which coloured metallic oxides have been mixed. The enamel colours are melted on at a gentle heat.

TITTLE (Chem.-Ztg. 1903, Repert. 12 Sprechsaal 1902, 1886) has prepared magnificent modern lustre-porcelain in all colours by thinly coating the glaze of the porcelain, which contains 2.5 % cobalt oxide and is burnt on in a sharp fire, with bismuth oxide, and then burning the objects in the muffle furnace (Seger cone 09). The porcelain is then coated with purple lustre (a gold-tin preparation to be obtained from HERÆUS) and this burnt in with a weak Dutch gold fire. A uranium-bismuth-gold lustre is then brought on to the porcelain and the whole burnt in the fusing muffle (Seger cone 015). The uranium-bismuth-gold lustre, which produces the real effect on the porcelain, is prepared by mixing 20 g uranium lustre with 10 g bismuth lustre and 1 g Dutch gold.

Porcelain pigments:

Johnson, Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Porcelain tubes.

Porcelain tubes:

Johnson, Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Porous earthenware see "EARTHENWARE", &c.

Portland cement see "CEMENT".

Potassium. K. A. W. 39.1. The manufacture is carried out in a manner similar to that of sodium but has been attended with much greater difficulty. Thus it can be obtained by heating a mixture of K_2CO_3 with C (such a mixture as is formed by carbonizing cream of tartar); the other processes for the production of Na have also been applied with more or less success to the manufac-

ture of K. Thus K_2CO_3 can be reduced with Al or Mg; by means of the latter K may also be obtained direct from KOH; the reaction is expressed by the equation $KOH + Mg = K + H + MgO$. The operation is carried out in distilling vessels; after the distillation is finished the receivers are dipped, together with the K contained inside, into petroleum and the metal scraped out after cooling; it can be purified by redistillation or by pressing through linen cloths.

According to Germ. Pat. 138368 potassium may be prepared by heating calcium carbide with potassium fluoride or a double fluoride to a red heat in the absence of air in a suitable vessel. The K distils over; the process is said to be extremely cheap. According to Germ. Pat. 140737 K is obtained by heating a mixture of aluminium and potassium fluoride (or potassium silicofluoride) in a distilling vessel: the K distils off at a low temperature and is obtained in the purest form. The process is without danger as no explosive potassium carbonyl can be formed; the Al is used in pieces about as big as peas.

According to the Engl. Pat. 19196 (1903) potassium aluminate mixed with coal or tar may be treated in the electric furnace; the potassium is volatilized in a current of an indifferent gas and then condensed.

LORENZ, CLARK and SACHER have worked out a process for obtaining K which does away with the formation of the heavy metallic "cloud" which spoils almost the whole yield. According to their data the fused caustic alkali is electrolyzed in an iron vessel between a sheet iron anode and an iron wire cathode; the wire is passed through the bottom of a magnesite cylinder the lower opening of which dips into the fused mass. When the cylinder is almost completely filled with K, it is allowed to cool, dipped into petroleum, and broken so that the potassium regulus can be obtained. The yield by this method is said to amount to 95 % of the theoretical quantity.

For other methods of preparation, see "SODIUM".

A lustrous, silver-white, crystalline metal, brittle when cold but soft as wax at ordinary temperatures. S. G. (at 15°) 0.865; M. P. 62.5°; B. P. 667°. It readily oxidizes in the air, decomposes H_2O at the ordinary temperature, and is kept like sodium.

The cheaper sodium is generally used instead of potassium.

Potassium:

Cannings. Great Hampton St., Birmingham.
Willy Manger, Dresden, Germany.

Potassium carbonates.

a) POTASSIUM CARBONATE. K_2CO_3 . Formerly obtained almost exclusively from wood ashes; beech wood ash, e. g., contains 15.4 % K_2CO_3 . In this process, which is of course only applicable where there is no other use to be made of the wood, the wood ash is first moistened with H_2O and then lixiviated with more water; after having been treated three times the residue is exhausted and can be used as a manure. The lyes (20° Bé strong) are evaporated to dryness in large pans and the dark brown residue ignited in order to destroy the organic substances. The potash obtained from plant ash has always a considerable amount of Na_2CO_3 and also contains KCl, K_2SO_4 and small amounts of insoluble salts.

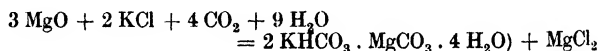
As the price of wood rose more attention had to be given to other methods of preparation. At present large amounts are obtained from the residual charcoal after purification of beet root-molasses: If the sugar has been precipitated from the molasses, or if the latter has been treated to give alcohol, the distiller's wash is left as a thin liquid (4° Bé). This is neutralized with $CaCO_3$, and, after the precipitate of $CaSO_4$ has settled, evaporated in a pan or vacuum to 40° Bé, dried in calcining furnaces, and finally burnt white in

the same (see "DISTILLER'S WASH"). This white burnt substance varies greatly in composition and contains between 30 % and 60 % K_2CO_3 , while the Na is lost during ignition. It is then ground between grooved rollers and systematically lixiviated. The lye flows off at a concentration of 27° Bé. It is evaporated to 40° Bé and allowed to clear while hot, when K_2SO_4 separates out. The clear solution is then allowed to cool to 27°, when (principally) KCl crystallizes. It is now concentrated to 50° Bé at the same time agitated by a stirring contrivance, and in this way the Na_2CO_3 is precipitated. After standing an hour the lye is drawn off into another pan, in which a mixture of KCl and K_2SO_4 crystallize out on being allowed to cool down to 50°. The lye is again drawn off and cooled down as far as possible and in this way sodium potassium carbonate $KNaCO_3 + 6H_2O$ precipitated. The mother liquor, after being freed from the crystals, is concentrated to 55–57° Bé, which causes Na_2CO_3 to be again precipitated. The clear solution is then brought into calcining furnaces, first evaporated to a thick pulp, and gradually heated to a red heat and at the same time constantly stirred; care must however be taken that the K_2CO_3 does not fuse. After being redissolved, concentrated and calcined, the commercial product is obtained.

In places where there are large wool washing establishments potash is obtained from the suint by washing the wool, evaporating the wash-water to dryness, subjecting the residue to dry distillation in retorts, and lixiviating the mixture of carbon and potassium salt with H_2O . The further process corresponds to the one described above, but it may be mentioned that suint has the great advantage of containing much less Na . About 5 % of the weight of wool is obtained as K_2CO_3 .

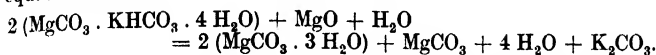
The method of obtaining K_2CO_3 from the Stassfurt (abraum) salts is, however, the most important. The crude KCl is converted into K_2SO_4 , and this further treated as in the *LEBLANC* soda process, i. e. it is heated with $CaCO_3$ and C . Thus mixtures of 150 kg sulphate, 130–160 kg limestone, and 65–80 kg of coal (as free as possible from ash) are heated together. The heating is carried out in reverberatory furnaces, and the K_2CO_3 is then systematically lixiviated: the lyes must not be heated above 40°. The lyes (22–30° Bé) are evaporated and the residue calcined, but in order to refine it the K_2CO_3 thus obtained must be redissolved in hot water, evaporated, and calcined again.

ENGEL's magnesia process which also starts from the KCl of abraum salts has attained a special importance in the last few years. ENGEL has found that KCl and $MgCO_3$, on being treated in aqueous solution with CO_2 , react according to the equation:—



that is, on the one hand the readily soluble $MgCl_2$ is formed, and on the other hand the sparingly soluble double salt, potassium magnesium carbonate. The latter is freed from the $MgCl_2$ solution by filtering, and then heated in closed vessels to 115°; when it is decomposed into insoluble $MgCO_3$, and soluble K_2CO_3 , with liberation of CO_2 . This process has been altered and improved by numerous patents (e. g. Germ. Pat. 55182) in such a manner that the double salt is freed from the $MgCl_2$ mother liquor by washing with magnesium bicarbonate solution. The double salt must not be washed with water as it is partly decomposed by this treatment. Magnesium bicarbonate may be prepared according to this patent by passing CO_2 into magnesia milk, or by treating the latter with CO_2 under pressure. A further improvement of the magnesia process is the subject of Germ. Pat. 135329 and 141808, according to which the potassium magnesium carbonate is suspended in H_2O or a or adilute K_2CO_3 solution, and treated with MgO or $Mg(OH)_2$ at

a temperature kept below 20° by means of cooling agents, according to the equation:—



In this way a concentrated solution of K_2CO_3 is obtained, and the MgCO_3 formed can be used again for converting a further quantity of KCl into potassium magnesium carbonate.

Numerous other improvements of the magnesia process have also been introduced; they all aim at obtaining the MgCO_3 as a salt with 3 mol. of water of crystallization, which can be returned to the cycle.

Germ. Pat. 143594 and 144742 for the preparation of crystalline magnesium carbonate with $3 \text{H}_2\text{O}$ may be mentioned. According to the former suspended magnesium carbonate is treated with an excess of gas containing CO_2 — allowing the percentage of CO_2 in the gas to increase in proportion to amount of the carbonate, while according to the second patent the magnesium hydroxide is suspended in dilute KCl solution and treated with CO_2 . — Further Germ. Pat. 143408 and 143595 for the preparation of potassium magnesium carbonate may also be mentioned. According to the former the heat evolved by the action of CO_2 on MgCO_3 solution is neutralized by artificial cooling, and the double salt is kept suspended in the liquid by a current of gas containing CO_2 in order to prevent it from decomposing. According to the other patent, after the formation of the MgCO_3 and before the addition of KCl , a part of the liquid is removed, and the rest enriched with KCl (which causes the latter to react more freely); the formation of the double salt is then brought about by passing in CO_2 .

Germ. Pat. 157354 is an addition to the above mentioned Germ. Pat. 135329 and 141808. To prevent the formation of amorphous basic magnesium carbonate in this process, the temperature must not be allowed to rise above 20° ; if this rule be observed the magnesium hydroxide may be employed even in great excess. On this account twice the theoretically necessary amount of magnesia can be added at the beginning, and the resulting mixture of $\text{MgCO}_3 + \text{Mg}(\text{OH})_2$ used again for the decomposition of a fresh amount of potassium magnesium carbonate.

Germ. Pat. 159840 allows the gases containing CO_2 to act under a pressure of at least 3 atmospheres to prevent as far as possible the formation of basic salts; if the gases contain less than 20—30 % CO_2 the pressure must be increased still more.

Germ. Pat. 143409 and 155007 aim at bringing about the decomposition of potassium magnesium carbonate so that the MgCO_3 is recovered as a salt with $3 \text{H}_2\text{O}$. With this object, according to the former patent, the decomposition is brought about with H_2O at a temperature not above 80° , and the $\text{MgCO}_3 \cdot 3 \text{H}_2\text{O}$ removed as quickly as possible to prevent it from being converted into $\text{MgCO}_3 \cdot 2 \text{H}_2\text{O}$. The second patent prescribes the prevention of the escape of CO_2 during the decomposition, or allows CO_2 to act directly on the $\text{MgCO}_3 \cdot 3 \text{H}_2\text{O}$ formed; in this process the temperature can be advantageously allowed to rise to boiling point.

Some of these patents appear to be contradictory to a certain extent; the details of the actual manufacture are still partly the secret of the various manufacturers.

As regards the electrolytical preparation of K_2CO_3 by decomposing KCl , see "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL". The details of the electrolytical methods of formation are for the greater part still kept secret, and it cannot at present be said whether these will always be able to compete with the *LEBLANC* process and (especially) the magnesia process, or displace them.

For the manufacture of flint glass K_2CO_3 perfectly free from sulphates is necessary. For this purpose an 80 % hydrated potassium carbonate is prepared by dissolving the ordinary once refined substance to 80° Bé, evaporating the clear settled solution in iron dishes to a pasty, consistency removing the source of heat, and shaking the mass until it is fine grained and completely dry.

Chemically pure K_2CO_3 cannot be obtained by recrystallization; it was formerly made from cream of tartar, while it is now prepared from potassium bicarbonate (q. v.) by evaporating either in enamelled iron dishes, or in silver dishes.

Pure K_2CO_3 is a solid white strongly alkaline mass. The salt $2 K_2CO_3 + 3 H_2O$ crystallizes from very concentrated solutions in large glassy crystals, which are converted at 100° into the salt $K_2CO_3 + H_2O$; at 135° the remainder of the water of crystallization escapes. 100 parts H_2O dissolve at 0° 89.4 parts; at 20° 112 parts; at 50° 121 parts; at 100° 156 parts; at 135° (B. P.) 205 parts K_2CO_3 .

Specific gravities and percentage of solutions of K_2CO_3 at 15° according to LUNGE.

S. G.	Degrees Baumé	K_2CO_3 , %	1 cub.met. contains K_2CO_3 kg	S. G.	Degrees Baumé	K_2CO_3 , %	1 cub.met. contains K_2CO_3 kg
1.007	1	0.7	7	1.231	27	23.5	289
1.014	2	1.5	15	1.241	28	24.5	304
1.022	3	2.3	23	1.252	29	25.5	319
1.029	4	3.1	32	1.263	30	26.6	336
1.037	5	4.0	41	1.274	31	27.5	350
1.045	6	4.9	51	1.285	32	28.5	366
1.052	7	5.7	60	1.297	33	29.6	384
1.060	8	6.5	69	1.308	34	30.7	402
1.067	9	7.3	78	1.320	35	31.6	417
1.075	10	8.1	87	1.332	36	32.7	436
1.083	11	9.0	97	1.345	37	33.8	455
1.091	12	9.8	107	1.357	38	34.8	472
1.100	13	10.7	118	1.370	39	35.9	492
1.108	14	11.6	129	1.383	40	37.0	512
1.116	15	12.4	138	1.397	41	38.2	534
1.125	16	13.3	150	1.410	42	39.3	554
1.134	17	14.2	161	1.424	43	40.5	577
1.142	18	15.0	171	1.438	44	41.7	600
1.152	19	16.0	184	1.453	45	42.8	622
1.162	20	17.0	198	1.468	46	44.0	646
1.172	21	18.0	211	1.483	47	45.2	670
1.180	22	18.8	222	1.498	48	46.5	697
1.190	23	19.7	234	1.514	49	47.7	722
1.200	24	20.7	248	1.530	50	48.9	748
1.210	25	21.6	261	1.546	51	50.1	775
1.220	26	22.5	275	1.563	52	51.3	802

Potassium carbonate is used in the manufacture of glass, in dyeing, bleaching and wool washing, for the preparation of soft soaps, and other potassium salts (especially potassium cyanide and potassium ferrocyanide), &c.

TEST. The sample to be tested must, immediately on taking, be uniformly mixed and powdered in a dry mortar, and then placed at once air-tight bottles, as it otherwise absorbs moisture from the air.

The chief things to be determined are: amount of moisture, total alkalinity, sodium carbonate, insoluble substances, potassium chloride, potassium sul-

phate, potassium silicate and, in more impure products, the caustic potash.

The amount of moisture is determined by heating 10 g substance in a platinum crucible until the weight is constant. In works the alkalinity is usually determined by weighing off 2.5 g, dissolving in distilled H_2O and titrating with H_2SO_4 . In the laboratory usually 5 g are weighed, dissolved, made up to 500 ccm, and 25 ccm (= 0.25 g potash) of this solution are taken and titrated with $1/10$ N-sulphuric acid at the ordinary temperature, adding 2 drops methylorange solution (1 g methylorange in 1 litre H_2O) as an indicator. The neutral point is shown by the colour turning from yellow into pink.

To determine the amount of Na_2CO_3 the carbonates are converted into the chlorides by evaporating with HCl, and if necessary precipitating the H_2SO_4 by means of $BaCl_2$. The following determination according to ROETTER and PRECHT is based on the different solubilities of NaCl and KCl in alcohol. 100 parts alcohol dissolve at 15° .

	90	92.5	95	% by weight.
Sodium chloride	0.345	0.223	0.146	parts.
Potassium chloride	0.073	0.043	0.028	parts.

If 20 g potash have been treated with HCl, &c., the resulting chloride mixture is washed with 90 % alcohol into a 110 ccm flask, and then thoroughly shaken for $1/2$ hour with 80 ccm of 90 % alcohol. The flask is then filled up to the mark with alcohol of same strength, and of this solution 50 ccm (= 10 g K_2CO_3) are taken, evaporated to dryness in a platinum dish, heated gently, and weighed.

The amount of insoluble substance is determined by dissolving 10 g K_2CO_3 , filtering through a weighed filter, washing with hot water, and weighing after drying at 100° .

To determine the amount of potassium chloride, 2–10 g K_2CO_3 (according to purity) are neutralized very exactly in a beaker with nitric acid — a drop of methylorange solution being added as indicator; then the amount of Cl is determined by titrating with $1/10$ N-silver nitrate, using K_2CrO_4 as an indicator.

Potassium sulphate is determined by dissolving 10 g K_2CO_3 in HCl, filtering, heating to boiling point, precipitating with $BaCl_2$, and weighing the $BaSO_4$.

Potassium silicate is estimated by dissolving 5 g K_2CO_3 in H_2O , filtering, adding HCl to the remainder, and evaporating to dryness in a platinum crucible. The residue is powdered, dissolved in HCl, heated, then diluted with H_2O , and the silica precipitated filtered off, dried, and weighed.

b) POTASSIUM BICARBONATE. $KHCO_3$. On passing CO_2 into a saturated solution of K_2CO_3 the less readily soluble $KHCO_3$ is precipitated. On a large scale pure potash solution is mixed with roughly ground wood charcoal the solution evaporated to dryness and converted into the bicarbonate by passing CO_2 over it. The product is dissolved in water at 70 – 80° and the salt obtained by crystallization.

Anhydrous, large transparent crystals of salty taste and slightly alkaline reaction. $KHCO_3$ is used chiefly for the preparation of pure K_2CO_3 .

Potassium compounds compare "ABRAUM SALTS".

1. POTASSIUM ACETATE. $KC_2H_3O_2$. The neutral potassium acetate is obtained by the saturation of $KHCO_3$ with acetic acid and evaporation to dryness if this substance is dissolved in acetic acid, the acid acetate $KC_2H_3O_2 \cdot C_2H_4O_2$ is produced.

2. POTASSIUM ALUM see "ALUMS".

3. POTASSIUM ANTIMONY TARTRATE, Tartar emetic, see "ANTIMONY COMPOUNDS".

4. **POTASSIUM ARSENATE.** KH_2AsO_4 . Obtained by fusing together equal parts of As_2O_3 and KNO_3 extracting the product and evaporating the solution. It forms white crystals and is used in the printing of textiles and to a certain extent in medicine.

5. **POTASSIUM BROMIDE.** KBr . Is usually obtained from ferrous bromide (see "BROMINE COMPOUNDS") by adding a solution of the bromide to a concentrated boiling solution of K_2CO_3 . The Fe precipitate is made dense by boiling for some time and is then separated from the KBr solution by putting through a filter press and the KBr solution evaporated. The substance is purified by dissolving in 1—1½ times its weight of H_2O evaporating, and allowing to crystallize slowly. According to Germ. Pat. 138008 bromine is added to a concentrated solution of KOH or K_2CO_3 to saturation, the mother liquor is separated from the separated salt, again saturated with KOH or K_2CO_3 and Br again added. These operations are repeated alternately until the amount of chlorine in the mother liquor is so great that it is necessary to work it up. The principal advantage of this process is that within certain limits the separation of the KBr can be carried out simultaneously without the necessity for evaporation.

Potassium bromide forms colourless crystals with a sharp salty taste, which dissolve easily in H_2O sparingly in alcohol, and remain unchanged on exposure to the air. The crystals are used in photography and medicine, besides being employed for the preparation of other bromine compounds.

6. **POTASSIUM CHLORATE.** KClO_3 . This product was formerly made by passing chlorine into lime water and converting the calcium chlorate thus formed into KClO_3 by means of KCl . For this process the lime water is placed in cast iron cylinders provided with stirring apparatus, into which the chlorine is passed. The calcium chlorate solution is allowed to settle or is filtered, decomposed with the theoretical quantity of KCl and then evaporated. The crude crystals are purified by fractional solution and recrystallization.

The above process is now almost completely replaced by electrolytical methods. If the hot solution of KCl is electrolyzed without a diaphragm, KClO_3 must be obtained, for the Cl and KOH which are first formed by the decomposition of KCl react further with the formation of the chlorate. The process is modified in various ways, as for instance the addition of chlorides or carbonates of alkaline earths or K_2CO_3 to the electrolytes. For details compare "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL" where the new patents for the production of chlorates are given.

Besides the electrolytical method of preparation the well known process invented some years ago by K. J. BAYER is becoming important, since it has the advantage of producing as a secondary product not CaCl_2 but the comparatively valuable zinc chloride. By this process (Engl. Pat. 17978, 1894), zinc oxide suspended in water is treated with a current of chlorine and the solution is further heated with the chloride of an alkali or the ZnO is suspended directly in a solution of the chloride, into which Cl is then conducted and the solution finally heated.

This substance forms glittering, colourless crystals with no water of crystallization which remain unchanged on exposure to the atmosphere. 100 parts of H_2O dissolve 3.33 at 0° , at 35° 12 parts, at 100° 60 parts of KClO_3 . It is used in the manufacture of matches and fireworks, also for oxidizing purposes, in dyeing and the preparation of chemicals; it is also used in medicine.

7. **POTASSIUM CHLORIDE.** KCl . Is found almost pure as sylvine in abraum salts; combined with MgCl_2 as carnallite; it is obtained from these two substances and also from kainite $\text{K}_2\text{SO}_4 + \text{MgSO}_4 + \text{MgCl}_2 + 6\text{H}_2\text{O}$, one of the abraum salts, by interaction between the MgCl_2 and the K_2SO_4 .

Compare "ABRAUM SALTS".



CHLORATE OF POTASH CRYSTALLIZING HOUSE

The carnallite and kainite are decomposed by water at different temperatures. The different solubilities of KCl and NaCl are of great importance in the preparation of pure KCl. Both of these salts dissolve in cold H_2O to almost the same extent, but the solubility of KCl increases with rise of temperature much more rapidly than that of NaCl, 100 parts of H_2O at 20° dissolve 36.3 parts of NaCl or 34.7 parts of KCl, at 100° 40.1 parts of NaCl or 56.6 parts of KCl. The separation of these two salts is assisted by the use of carnallite since the $MgCl_2$ (obtained by the dissociation of the carnallite in warm solution) is readily soluble and causes the NaCl to salt out more readily than the KCl. The whole of NaCl can therefore be separated and a pure solution of KCl obtained, from which the salt itself is then produced by evaporation and recrystallization.

According to Germ. Pat. 135722 the carnallite employed for the production of KCl is dissolved by special methods at the source.

Colourless, transparent regular crystals with a pure salty taste. 100 parts of H_2O dissolve at 0° , 28.5 parts at 15° , 33.4 parts, and at 110° , 59 parts of KCl; potassium chloride is almost insoluble in alcohol. It is employed for the preparation of KNO_3 , of potash alum, potassium chlorate and potassium chromate; it also serves as a manure.

Potassium chloroplatinite K. 2 PFe 14:

Johnson's, Cross St., Finsbury, London.

8. POTASSIUM CHROMATE.

a) Neutral potassium chromate (yellow) K_2CrO_4 . Obtained by fusing chrome iron ore Cr_2FeO_4 with K_2CO_3 and KNO_3 . The melt is ground and the K_2CrO_4 extracted with hot water. The solution, after the Al_2O_3 and SiO_2 have been precipitated by the addition of crude acetic acid, is concentrated by evaporation and allowed to crystallize. Other methods of preparation are also used; a large quantity of K_2CrO_4 is produced from $K_2Cr_2O_7$ by saturating a solution of the latter with K_2CO_3 , evaporating and crystallizing. According to Germ. Pat. 143251 certain oxidizing agents like PbO_2 , MnO_2 , $KMnO_4$, &c., which are not decomposed by hot dilute H_2SO_4 , are used for the electrolytical decomposition of the chrome iron ore. The oxidizing agents can be automatically regenerated in the solution by electrolysis. According to Germ. Pat. 143320 and 146491 the solution of some salt is used for preparing potassium chromate. A diaphragm and an anode of chromium or a chromium alloy are used in the electrolysis. An insoluble anode can also be used in place of the above, in which case the electrolyte consists of a mixture of chromium sulphate and potassium sulphate kept alkaline by the addition of lime. Finally mention should be made of Germ. Pat. 151132 by which chrome iron ore is fused with caustic alkali in presence of air. Lime is added to the fused substance to precipitate the aluminate and silicate, and the chromate is separated from excess of KOH by evaporation. This method is said to be cheaper than those hitherto employed, although it involves the use of KOH, since all the KOH, not combined in the form of chromate, can be recovered and used again; the low temperature at which this process is carried out renders it more economical as regards fuel.

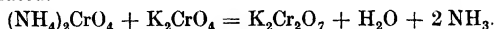
According to Germ. Pat. 163814 chrome iron ore is fused with NaOH at $500-600^\circ$. Oxygen carriers such as manganates, permanganates, CuO, PbO and Fe_2O_3 are added, and air is led through the fused mass. An improvement of this method is described in Suppl. of Germ. Pat. 171089.

The crystals are anhydrous and pale yellow in colour. They have a cooling and bitter metallic taste, readily soluble in water, insoluble in alcohol. K_2CrO_4 is used in dyeing and for the preparation of chrome yellow and chromium ink.

TEST. The amount of CrO_3 is determined by strongly acidifying the aqueous solution with H_2SO_4 , reducing with an excess of Mohr's salt, (ferrous ammo-

niun sulphate), and (titrating in the weak solution) the excess of FeSO_4 , with KMnO_4 solution. Very often the K_2CrO_4 contains considerable quantities of K_2SO_4 . The strong aqueous solution acidified with HCl and treated with BaCl_2 gives an insoluble precipitate of BaSO_4 . If this impurity is to be quantitatively determined the weak hydrochloric acid solution is precipitated with BaCl_2 and the precipitate digested with HCl and alcohol to remove the BaCrO_4 .

b) **POTASSIUM BICHROMATE.** $\text{K}_2\text{Cr}_2\text{O}_7$. This substance is produced by roasting ground calcined chrome iron ore with quick lime and K_2CO_3 to a red heat and extracting the K_2CrO_4 and CaCrO_4 produced with a solution of K_2CO_3 or K_2SO_4 . If the solution is then slightly acidified with H_2SO_4 , and evaporated $\text{K}_2\text{Cr}_2\text{O}_7$ crystallizes out. Accordindi to Germ. Pat. 128194 the pulverized mixture, which contains about equal molecular proportions of K_2CrO_4 (or Na_2CrO_4) and CaCrO_4 , is diluted with water and treated with CO_2 and NH_3 till all the CrO_3 has passed into solution and the Ca is precipitated as CaCO_3 . The undissolved and precipitated substances are then removed and the solution boiled to remove the NH_3 from the $(\text{NH}_4)_2\text{CrO}_4$, from which finally the solution of $\text{K}_2\text{Cr}_2\text{O}_7$ or $\text{Na}_2\text{Cr}_2\text{O}_7$ is obtained and finally evaporated.



According to Engl. Pat. 2211 (1903) the calcium chromate obtained by fusing chrome iron ore is treated with water and such quantities of K_2CO_3 , NH_3 and CO_2 that a mixture of K_2CrO_4 and $(\text{NH}_4)_2\text{CrO}_4$ in equi-molecular proportions remains in the solution, while CaCO_3 is precipitated. The filtered solution is boiled, the NH_3 escapes and a solution of $\text{K}_2\text{Cr}_2\text{O}_7$ is obtained. The whole process appears to be a modification of the one given above.

The crystals, which are anhydrous and not affected by the air have a bitter metallic taste, are red in colour, and have a caustic and poisonous action. 100 parts of H_2O dissolve 5 parts at 0° , 29.1 parts at 40° , 102 parts at 100° of the substance, which is insoluble in alcohol. It is used in the manufacture of coal tar colours, for chromium preparations, as a mordant, in the manufacture of matches, for the purification of wood vinegar, in photography, &c.

TEST. The CrO_3 is determined by titration and the SO_3 by gravimetric analysis as given above in the test for neutral potassium chromate. A percentage of 67.5—68.0 % CrO_3 is guaranteed for commercial $\text{K}_2\text{Cr}_2\text{O}_7$.

9. **POTASSIUM CYANIDE.** KCN . Formerly this substance was obtained by fusing 8 parts of anhydrous potassium ferrocyanide with 3 parts of calcined K_2CO_3 in a covered iron vessel. The product contains potassium cyanate, the formation of which can, however, be prevented or at least decreased by the addition of C during the fusion. The mixture melts more readily if Na_2CO_3 is used instead of K_2CO_3 . In this way the so-called cyanide salts, a mixture of KCN and NaCN , are obtained. Pure KCN is obtained by heating dry ferrocyanide of potassium in covered iron crucibles, $\text{K}_4\text{Fe}(\text{CN})_6 = 4 \text{KCN} + \text{FeC}_2 + \text{N}_2$. The iron carbide settles at the bottom of the crucible; the KCN is poured off, extracted with diluted alcohol and after the alcohol is distilled off, the salt is fused. Since an impure product is obtained by fusing potassium ferrocyanide with K_2CO_3 in an iron crucible, it has been customary for some time to add metallic sodium, when all the cyanogen is obtained in the form of cyanide.

Recently KCN has been made in decreasing quantities from potassium ferrocyanide; the greater amount is now prepared synthetically according to four methods namely:—1. **SIEFERMANN'S** (Stassfurt), 2. **BELBY'S** (Glasgow), 3. **RASCHEN** process (United Alkali Co.), 4. **IMPROVED CASTNER** process.

According to **SIEFERMANN** (Germ. Pat. 51260 and 51562) a mixture of coarsely ground charcoal and K_4CO_3 is brought to a bright red heat in retorts

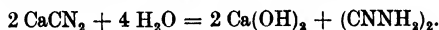
and then a uniform current of NH_3 passed over. The fused mass is lixiviated until the S. G. 1.4 is reached and then treated with K_2CO_3 ; on cooling, the greater part of the KCN separates out and is purified by being centrifuged and recrystallized. The Germ. Pats. 126441, 126442 and 133259 treat of alterations of the latter process.

BELBY'S process is a modification of SIEPERMANN'S; BELBY does away with the difficulties of lixiviation in the preparation of cyanide by adding cyanide already prepared to the mixture, the melting point is thereby depressed and in this way a high percentage of cyanide attained in the fused mass. The Amer. Pat. 787380 also comes under this category; according to this method the mixture of a cyanide of an alkaline earth (which may contain cyanide) with alkali carbonate is heated — with or without the addition of charcoal — to a red heat. The fused mass is then lixiviated, after which the alkaline earth compounds are precipitated with NaHCO_3 , and the filtered solution concentrated.

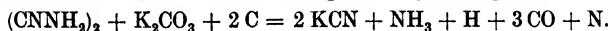
According to the process of the United Alkali Co., cyanide may be obtained by the oxidation of sulphocyanide compounds with HNO_3 , but this (theoretically) very elegant process proves to be very complicated in practice. Under this heading is also included the Germ. Pat. 145748 according to which the cyanogen gases which also contain O from the air and nitric oxide, formed by the oxidation of sulphocyanide salts with HNO_3 , are not absorbed as usual by means of caustic alkalies, but are passed at a dark red heat over alkaline carbonates. Germ. Pat. 160637 may be classed in this group; gases containing HCN are passed over solid caustic alkali which becomes heated to a temperature which, though it is below the M. P. of the caustic alkali, is still above the point of evaporation of the water formed by the reaction.

The fourth of the processes employed is that of CASTNER protected by Germ. Pat. 126241; as alkali metal is the direct starting point it is only of importance for NaCN. (See SODIUM CYANIDE in the article "SODIUM COMPOUNDS").

The preparation of alkali cyanides according to FRANK and ERLWEIN (Amer. Pat. 775953 and 785161) is quite new. Here the N of the air is the starting point and from this calcium cyanamide (see "CALCIUM COMPOUNDS") is obtained. If the calcium cyanamide is lixiviated with water dicyandiamide is obtained $(\text{CNNH}_2)_2$ as a white salt according to the equation:



By simply re-fusing the dicyandiamide with potash and charcoal white 100 % KCN is obtained; the reaction is expressed by the equation:—



Germ. Pat. 149594 starts from N and combines it with the help of a carbide exactly as in the FRANK and ERLWEIN'S process. A mixture of carbide and coarsely ground coke is fused in an electric furnace and then the mass treated, after cooling below the M. P. of the carbide, in the porous state with N, until it just solidifies. The conversion of the calcium cyanide into KCN offers no further difficulties.

Germ. Pat. 176080 deals with the preparation of cyanide from the nitrides. Many metals give rise to these compounds, but Ca and Mg nitrides are usually employed for this purpose.

The nitrides are heated with alkaline carbonates and coke: the mixture gets very hot and cyanide is formed throughout the mass without the further addition of heat.

Increasing amounts of KCN are at present formed by passing HCN into KOH; with regard to the methods by which HCN is obtained, see "CYANOGEN COMPOUNDS".

Methods for obtaining cyanides of the alkali metals from gas purifying residues, from molasses and many other processes, cannot be here treated, as most of them are without great practical importance. A great amount of work is being done at present in this direction — a proof that the demand for this salt is very great. The same may be said of the processes for the purification of KCN; according to the Germ. Pat. 128360 it may be obtained by placing the solid crude KCN in a sieve-crucible which is heated from the outside. The pure cyanide melts and can be run off by suitable contrivances while the impurities remain behind on the sieve inside the crucible. Another purifying process is that of the French Pat. 347373. In this process the crude cyanide is distilled in the presence of H_2O and ammonium salts: the NH_4CN which passes over is caught in caustic alkali.

Colourless crystals, or after melting, a crystalline mass; tastes sharply alkaline, and possesses a smell resembling bitter almonds, decomposes in the air (CO_2) with formation of HCN, is very readily soluble in H_2O , sparingly soluble in alcohol, and is extremely poisonous. It is employed in electroplating, in photography, for the preparation of cyanide compounds and for the extraction of gold, as well as for the preparation of numerous organic compounds.

Potassium cyanide:

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10. POTASSIUM IRON SULPHATE (Iron alum), see "ALUM".
11. POTASSIUM FERRICYANIDE, see "IRON COMPOUNDS".
12. POTASSIUM FERROCYANIDE, see "IRON COMPOUNDS".
13. POTASSIUM FLUORIDE. KF obtained by neutralizing HF with K_2CO_3 and evaporating to the point of crystallization. Acid potassium fluorides of the formula $KF \cdot 3HF$, $KF \cdot 2HF$ are known. The preparation of potassium fluoride must be carried out in vessels of platinum.
14. POTASSIUM HYDROXIDE. KOH. In order to obtain solid caustic alkali the lye is evaporated further in polished cast iron boilers; if the preparation is to be perfectly free from Fe the evaporation must — as soon as the lye has reached the S. G. 1.16 — be continued in vessels of pure silver; during the concentration the K_2CO_3 and K_2SO_4 , which separate out, are removed. As soon as a sample of the mass solidifies on cooling it is cast into sticks in silver moulds, or continually stirred while cooling in the boiler. The preparation is purified by dissolving in alcohol.

In the electrolytical preparation of KOH from KCl according to the equation I: $KCl = K + Cl$ and II: $K + H_2O = KOH + H$ a great number of difficulties had to be overcome before attempts to render it serviceable in practice were successful. The operation is carried out either in vessels in which the anode and cathode chamber are separated by a diaphragm or in cells without a diaphragm. The anodes consist as a rule of gas carbon (or platinum, iron sulphide, calcium silicide, &c.), the cathodes of mercury or iron. Numerous proposals have been made with regard to the apparatus as well as to the details of the process; those which have proved themselves good are still to a great extent the secret of the firms concerned. For fuller information concerning the electrolytical preparation of KOH, see "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

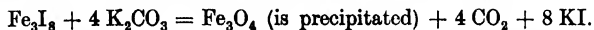
The removal of the water from KOH has caused many difficulties, because vessels of Fe and Ni are very strongly attacked at a red heat so that these metals afterwards occur as impurities. If Ni be used (according to Germ. Pat. 82876) potassium peroxide is formed as a by-product by electrolytical decomposition; this impurity is objectionable for many purposes (e.g. the indigo fusion). All these faults are avoided by French Pat. 352076 according to which — starting from KOH of 50° Bé — the removal of the water is carried

out under diminished pressure at 260° , that is, below the melting point of the KOH; the mass becomes thick and solid and falls to a powder when properly stirred.

Fused potassium hydroxide is colourless and odourless, crystalline, a very powerful caustic, readily soluble in H_2O and alcohol; it deliquesces quickly in the air and readily absorbs CO_2 . It is used for the manufacture of soft soaps, oxalic acid, as a caustic, for drying gases and liquids, as well as for the absorption of CO_2 . Sodium hydroxide is now usually employed instead of KOH.

15. POTASSIUM HYPOCHLORITE, see "BLEACHING", (EAU DE JAVELLE) and "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

16. POTASSIUM IODIDE. KI. Is obtained either from iodine and pure KOH ($6 KOH + 3 I_2 = 5 KI + KIO_3 + 3 H_2O$) or from ferrous iodide and K_2CO_3 . Instead of ferrous iodide, FeI_2 —which is obtained by the direct combination of I and iron filings in presence of water—ferrous iodo-iodide Fe_3I_8 , which is obtained directly by adding I to the green FeI_2 solution, can be employed with better result. The resulting solution is boiled with K_2CO_3 :



The cuprous iodide, obtained in large amounts from the mother liquors of Chili saltpetre, is converted by the action of H_2S and addition of $KHCO_3$ into KI.

Colourless and odourless, very salty and somewhat bitter tasting crystals, readily soluble in H_2O , sparingly in alcohol. The aqueous solution dissolves a great amount of iodine with formation of KI_3 . KI is used chiefly in photography and medicine.

17. POTASSIUM MAGNESIUM SULPHATE. $K_2SO_4 \cdot MgSO_4$. Is obtained according to different methods from kainite and schoenite (see "ABRAUM SALTS"). According to BRECHT the crude kainite is heated in iron boilers under a pressure of 2—4 atmospheres with a lye which is saturated with potassium magnesium sulphate and NaCl. Potassium bimagnesium sulphate is formed which is known as BRECHT's double salt. It is calcined and ground and brought directly into commerce as potassium magnesium sulphate. It is used almost exclusively as manure.

18. POTASSIUM METABISULPHITE, see No. 34 b "POTASSIUM SULPHITE".

19. POTASSIUM MOLYBDATE. The common salt potassium trimolybdate $K_2Mo_3O_{10}$ is obtained by fusing together 1 mol. of molybdic acid with 2 mol. K_2CO_3 and extracting the fused mass with boiling H_2O , or by saturating boiling caustic potash solution with molybdic acid.

Fine glistening needles, which are almost insoluble in cold, readily soluble in boiling water.

20. POTASSIUM NITRATE, see "SALTPETRE".

21. POTASSIUM NITRITE. KNO_2 . Obtained by bringing KNO_3 (either alone or mixed with galena) into a red hot crucible, or by melting KNO_3 with lead or copper turnings. The French Pat. 353467 aims at the recovery of the large quantity of lead oxide obtained as a secondary product in the nitrite manufacture, by reducing it to metallic lead.

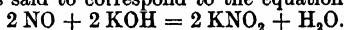
Of recent years numerous other methods for the manufacture of nitrites have been proposed. Thus the process of the Germ. Pat. 117298 consists in passing SO_2 (as free as possible from air) over a mixture of alkali nitrate (in this case KNO_3) and the oxide or carbonate of an alkaline earth which has been heated until it almost sinters; the reaction can be expressed by the following equation: $KNO_3 + CaO + SO_2 = KNO_2 + CaSO_4$. On a large scale the necessary thorough mixing of CaO and KNO_3 is attained by slaking caustic lime with a saturated KNO_3 solution; the yield is said to be almost quantitative and the separation from the insoluble gypsum can be carried

out very easily. According to the more recent Germ. Pat. 138029 saltpetre can be reduced with sulphites; the KNO_3 is melted in the presence of KOH and anhydrous sulphite is allowed to act on the fused mass at a temp. of $320\text{--}420^\circ$; the whole must be thoroughly stirred during the reaction. The nitrite formed is obtained by lixiviation with nitrite mother liquor and by crystallization. If all overheating is carefully avoided the yield is almost theoretical.

Germ. Pat. 160671 prepares KNO_2 by fusing saltpetre with lime and graphite, and lixiviating the nitrite from the resulting mass, while the residue is returned to the process again.

According to French Pat. 335229 NH_3 mixed with air or O is passed over metallic oxides (such as Fe_2O_3 or CuO ; it is advantageous to use ground and roasted pyrites) heated to $650\text{--}750^\circ$, and the resulting nitrous anhydride passed into a solution of KOH or K_2CO_3 .

Attempts to make use of the nitrogen of the air have also been directed to the nitrite manufacture. According to the French Pat. 346066 the gaseous compounds of N and O obtained by electric discharges in air are passed into caustic lye, when a mixture of nitrite and nitrate is formed. The same reaction is treated of in the French Pat. 350619. In this case, however, nitrite free from nitrate is obtained because the gases obtained by the electric discharge in air are passed directly into an absorption vessel filled with caustic alkali. The action is said to correspond to the equation



According to French Pat. 363643 nitrite is obtained from NO and O by keeping the temperature at 300° . In this way the further oxidation to N_2O_4 is prevented. The carbonates of the alkalies or alkaline earth hydroxides are used to absorb the gas.

Colourless, ill-formed crystals which deliquesce in the air and readily dissolve in H_2O but not in alcohol. It is used for the preparation of azo-compounds, ethyl nitrite, &c.

22. POTASSIUM OXALATES.

a) NEUTRAL POTASSIUM OXALATE $\text{K}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$. It was formerly obtained by the neutralization of oxalic acid with K_2CO_3 and evaporating down to the point of crystallization. Now the oxalates can be prepared according to GOLDSCHMIDT's process from salts of formic acid: thus potassium oxalate can be obtained (Germ. Pat. 111078) by heating a mixture of potassium formate and K_2CO_3 . Germ. Pat. 144150 provides in the same process for the addition of already prepared potassium oxalate by the heating of the formate—this is said to simplify the process and increase the yield. According to Germ. Pat. 161512 when heating the formate a small amount (not above 5%) of free alkali should be added.

b) POTASSIUM BINOXALATE (acid potassium oxalate; KLEE's salt). $\text{KHC}_2\text{O}_4 + \text{H}_2\text{O}$. Obtained by saturating oxalic acid with K_2CO_3 , dissolving an equal amount of oxalic acid in the liquid and evaporating till the solution crystallizes, or from the neutral salt by the addition of a corresponding amount of oxalic acid. The commercial salt contains usually potassium tetroxalate $\text{KH}_3(\text{C}_2\text{O}_4)_2 + 2\text{H}_2\text{O}$.

KHC_2O_4 forms colourless poisonous crystals which are unchanged in the air, have a bitter taste and an acid reaction, soluble in 25 parts of cold H_2O and in 14 parts hot H_2O . Finds the same use as oxalic acid.

c) POTASSIUM TETROXALATE (Potassium quadrioxalate). $\text{KHC}_2\text{O}_4 + \text{H}_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{O}$. This salt, which was recommended by KRAUT in place of oxalic acid for determining the strength of standard solutions because it can be prepared pure and does not alter in the air, is obtained by mixing a hot saturated of potassium oxalate with the theoretical amount of a hot saturated oxalic acid solution; the salt can be purified by repeated crystallization.

23. **POTASSIUM OXIDE.** K_2O . Until a short time ago it was still a matter of uncertainty as to whether K or Na were able to form normal anhydrous oxides. Now the preparation of these oxides can be carried out (see **SODIUM OXIDE** under "SODIUM COMPOUNDS"); thus to obtain K_2O (Germ. Pat. 143216) potassium nitrate (or nitrite) is heated with metallic potassium in the proportions corresponding to the equation $KNO_3 + 5K = 3K_2O + N$. This process must be carried out in the absence of air, and a small excess of K must be present so that the K_2O is free from peroxide. K_2O forms a grey crystalline mass on cooling, which quickly turns into the yellow peroxide in the air. It reacts very strongly with H_2O and becomes partly oxidized; black drops of fused K_2O_2 are formed which fly about. (For further methods of formation see **SODIUM OXIDE** under "SODIUM COMPOUNDS".)

24. **POTASSIUM PERCHLORATE.** $KClO_4$. It is prepared by heating $KClO_3$ until the mass, which is at first fluid, becomes pasty and the evolution of O ceases. The mass, which now consists of a mixture of perchlorate and chloride ($2KClO_3 = KClO_4 + KCl + 2O$), is lixiviated with cold water, KCl goes into solution, while the very sparingly soluble $KClO_4$ remains behind. The latter is dissolved in boiling water and purified by recrystallization. With regard to the electrolytical manufacture see under "PERCHLORATES" and "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

Anhydrous crystals with a slightly cooling taste. 1 part dissolves in 70 parts of cold H_2O ($10^\circ C$) and in 6 parts of boiling H_2O . As it is less readily decomposable than the chlorate it can be used with advantage instead of the latter; it also finds employment in the manufacture of explosives on account of its high percentage of oxygen.

25. **POTASSIUM PERCARBONATE.** $K_2C_2O_6$. It is formed by the electrolysis of a saturated aqueous solution of K_2CO_3 at -10° in the anode chamber. In the dry state it is colourless and stable, in the moist state it is coloured blue and is unstable. It decomposes in warm aqueous solution, when the O liberated acts as an oxidizing agent; the aqueous solution is decomposed by dilute acids with the formation of H_2O_2 . It is said to be a bleaching agent; it is also employed in photography to destroy fixing salt.

26. **POTASSIUM PERMANGANATE.** $KMnO_4$. Can be prepared by mixing 500 kg KOH (S. G. 1.44) with 105 kg $KClO_3$ and 180 kg of pulverized MnO_2 , evaporating to dryness and heating the cooled powder in crucibles until the mixture is pasty. The fused mass which consists of K_2MnO_4 is converted into permanganate by boiling with water and passing in CO_2 . The solution is filtered through gun cotton, evaporated, and allowed to crystallize. The oxidation of K_2MnO_4 to $KMnO_4$ can also be brought about with the help of Cl as well as by the electric current. According to Germ. Pat. 118232 ozone is used for converting the fused manganate into permanganate which results in a quantitative yield. A very concentrated solution is employed and ozonized air passed through; the $KMnO_4$, which is sparingly soluble in the strongly alkaline solution, is precipitated in the crystalline state and can be obtained by centrifuging.

Blackish red, glistening crystals with a metallic-green lustre which dissolve in 12 parts H_2O at $20^\circ C$. The solution is a strong oxidizing agent. $KMnO_4$ is used for mordanting wool, for bleaching textile fibres, for purifying NH_3 and CO_2 ; it is employed as a disinfecting and oxidizing agent, in medicine, in photography, and for the preparation of oxygen.

TEST. The solution acidified with H_2SO_4 is completely decolorized by warming with a small amount of oxalic acid, and gives on supersaturating with NH_3 and addition of $(NH_4)_2S$ a flesh-coloured precipitate of MnS . The presence of chlorides can be shown by heating the salt with dilute H_2SO_4 ; Cl is evolved which can be identified by the smell or (in small amounts) by means of

KI starch paper. The percentage of the purer commercial varieties is determined by titration of the dilute solution, acidified with H_2SO_4 , with an iron solution of known strength. To estimate the H_2SO_4 the solution is boiled with a large amount of HCl and the H_2SO_4 precipitated with BaCl_2 solution.

27. **POTASSIUM PERSULPHATE.** $\text{K}_2\text{S}_2\text{O}_8$. See "PERSULPHATES".

28. **POTASSIUM PHOSPHATE.** The neutral potassium orthophosphate K_3PO_4 is obtained by heating phosphoric acid with excess of K_2CO_3 , dissolving the mass in H_2O , and evaporating; it forms small crystalline needles readily soluble in H_2O .

The usual salt (dipotassium phosphate) K_2HPO_4 is obtained by saturating H_3PO_4 with K_2CO_3 until the reaction begins to be alkaline.

The other acid salt monopotassium phosphate KH_2PO_4 is obtained by the addition of H_3PO_4 to K_2CO_3 solution until litmus paper is turned red, and then evaporating. It forms acid-tasting crystals which readily dissolve in H_2O .

29. **POTASSIUM SULPHOCYANIDE.** KCNS . It is prepared by double decomposition of the solution of barium sulphocyanide (see "BARIUM COMPOUNDS") or of calcium sulphocyanide (see "CALCIUM COMPOUNDS") with K_2SO_4 or K_2CO_3 . Further it can be obtained by the distillation of ammonium sulphocyanide solution (see "SULPHOCYANIDE COMPOUNDS") with KOH or K_2CO_3 . Finally it may also be prepared from copper sulphocyanide (see "COPPER COMPOUNDS") by decomposing the latter with potassium sulphide.

The KCNS solutions are evaporated to 45°Bé and on cooling the salt crystallizes out without any water of crystallization.

30. **POTASSIUM SILICATE**, see "WATER GLASS".

31. **POTASSIUM SULPHATES.**

a) **NEUTRAL POTASSIUM SULPHATE.** K_2SO_4 . It is obtained from kainite and schoenite (see "ABRAUM SALTS"). The former salt is first converted into potassium magnesium sulphate and this decomposed with KCl . K_2SO_4 is obtained in a manner exactly analogous to that used for Na_2SO_4 by the decomposition of KCl with H_2SO_4 in the sulphate furnaces.

Hard, anhydrous slightly-bitter, salty tasting crystals, sparingly soluble in H_2O , insoluble in alcohol. It is used for the manufacture of potash alum, glass, and as an artificial manure.

b) **POTASSIUM BISULPHATE** (Acid potassium sulphate). KHSO_4 . Obtained from the above with excess of H_2SO_4 .

32. **POTASSIUM SULPHIDE.** Compounds of K with S . Only those polysulphides have any technical importance which have more than 1 atom of S for every 2 atoms of K . Liver of sulphur is a mixture of polysulphides and is obtained by fusing together 1 part of S with 2 parts of dry K_2CO_3 , or by the wet method, by the evaporation to dryness of a mixture of 10 parts K_2CO_3 , 4 parts S and 3 parts H_2O . Liver of sulphur is a yellowish-brown (afterwards yellowish-green) alkaline, caustic, poisonous mass readily soluble in H_2O and alcohol. It decomposes in the air with the evolution of H_2S . It is used especially for the preparation of sulphur baths.

According to French Pat. 319187 in order to obtain alkali sulphides the sulphates of the alkalis are mixed with somewhat more charcoal than is necessary for the conversion into the monosulphides and the mixture then exposed to the heat of an electric furnace (electric arc or resistance). The process must be carried out in absence of air.

33. **POTASSIUM SULPHITES.**

a) **POTASSIUM SULPHITE.** K_2SO_3 . It is obtained by passing SO_2 into a solution of K_2CO_3 until all the CO_2 has been expelled.

Bitter tasting, strongly alkaline, somewhat deliquescent crystals, very readily soluble in cold H_2O , less easily soluble in hot H_2O , almost insoluble in alcohol. It is brought into commerce both in the solid state and in solution.

b) **POTASSIUM BISULPHITE** (acid potassium sulphite). KHSO_3 . Obtained by supersaturation of concentrated K_2CO_3 solution with SO_2 . On being heated it yields potassium pyrosulphite $\text{K}_2\text{S}_2\text{O}_5$ for which the inappropriate name potassium metabisulphite has become general.

34. **POTASSIUM TARTRATE** (potassium bitartrate), see "CREAM OF TARTAR".

35. **POTASSIUM SODIUM TARTRATE**. $\text{KNaC}_4\text{H}_4\text{O}_6 + 4 \text{H}_2\text{O}$. Obtained from crude cream of tartar and the calcium tartrate contained in it by the addition of the theoretical amount of K_2CO_3 and Na_2CO_3 . H_2S precipitates Fe and Cu from the solution, the CO_2 is expelled by boiling, and the solution then evaporated until it crystallizes.

It forms large colourless, cool and slightly salty-tasting crystals, readily soluble in H_2O , sparingly in alcohol. Is used in medicine and also in analytical chemistry.

36. **POTASSIUM TUNGSTATE**. K_2WO_4 . Prepared by adding 1 part of powdered wolframite to 1 part of fused K_2CO_3 and boiling the resulting fused mass with H_2O ; or by dissolving tungstic acid in KOH .

Hygroscopic salt, which is soluble in an equal weight of cold water, insoluble in alcohol.

Potassium metatungstate $\text{K}_2\text{W}_4\text{O}_{13}$ and potassium paratungstate $\text{K}_{10}\text{W}_{12}\text{O}_{41}$ are also known.

37. **POTASSIUM XANTHATE** see "CARBON BISULPHIDE".

Potassium compounds:

Willy Manger, Dresden, Germany.

Praseodymium see "DIDYMIUM".

Precipitate, red, see "MERCURY COMPOUNDS".

Preparing salts (sodium stannate), see "SODIUM COMPOUNDS".

Presses.

Presses:

W. Stannm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Hydraulic Presses:

Wegolin & Huebner A.-G., Halle a. d. S., Germany.

Primuline. A coal-tar dyestuff. See "THIOBENZYL DYESTUFF" and "IN-GRAIN COLOURS".

Printer's ink. The most important and most used is printing black. Printing black is made of the soot of oil, resin or naphthalene, mixed in special mills with the best varnish to a fine, smooth, plastic mass. Compare "Soot". The varnish is often first mixed and melted with colophony and soap, the soot being added after cooling. The colour is often improved by adding finely ground indigo or Paris blue. Germ. Pat. 182221 treats of the preparation of a printer's ink in which the carbon is replaced by magnetic iron oxide obtained by special methods from ferrous salts.

Coloured printing inks are made on the same principle; a light coloured varnish being mixed with suitable mineral colours, such as the following:

RED. Antimony sulphide, chrome red and vermilion.

BLUE. Paris blue, ultramarine.

GREEN. Chrome green, Schweinfurt green.

YELLOW. Chrome yellow, chrome orange.

BROWN. Burnt ochre, Cassel brown, mahogany brown.

WHITE. Lead white, zinc white.

PURPLE. Crimson, and varnish colours.

The lighter shades are obtained by adding zinc white to the various colours. The colours given in no way exhaust the list of those in use; every factory has its own methods, which are not published, for making colours.

Composition for printers' rollers:

E. T. Gleitsmann, Dresden, Germany.

Printing, of cottons, &c. The material is printed by putting through copper printing rollers on which the pattern is deeply cut. To prevent the liquid colour or mordant from spreading, these substances are mixed with some thickening material such as starch, dextrine, albumen, gum arabic, tragacanth or gelatine. The printed stuffs are dried either by passing over heated steam plates or in steam chambers; or again in some cases hot air chambers are used. The pattern on the dried stuff is then fixed by steaming, that is by drawing the material through a steam boiler.

The thickened colour is either pressed directly on to the textile (direct printing) or substances, the so-called reserves, are printed on, these substances being such as prevent the parts covered from being dyed by the coloured bath into which the stuff is then placed (reserve or resist printing). Another method is: — first to dye the whole piece and then to print with agents which destroy the colour within the pattern (discharge printing).

Direct cotton dyes are not very frequently used since they are often not fast to washing. Compare "SUBSTANTIVE DYES". They are thickened with albumen and printed direct on to the material; or white patterns are made on the dyed material by printing stannic salts, acetate of tin, or powdered zinc + NaHSO_3 over the colour. The stuff is then steamed, washed, and dried. This process is termed **CHEMICAL DISCHARGE WORK**, or discharge printing. This method is well adapted for use with azo colours, as they are converted by the above-named reagents into colourless products. If the discharge work is to be itself coloured the chemicals are mixed with colours which are not affected by the reagents. In this way coloured patterns on material of another colour are obtained.

BASIC COLOURS (q. v.) are usually mixed with tannin and acetic acid before printing. During the process of steaming the latter evaporates and the tannin colour remains as an insoluble dye. After steaming the material must be drawn through a warm bath of tartar emetic to render the colours still more fast. The textile can also be printed with tannin, drawn through tartar emetic, and finally dyed with basic colours; in these cases, only the pattern made by the mordant will remain on washing.

MORDANT DYES are thickened, mixed with basic salts, metallic oxides, chromium, iron or aluminium oxide mordants, and acetic acid and then steamed. As the lake is only formed after steaming, mordant colours are sometimes termed steam colours. Compare "MORDANT COLOURS". Another method is to print the material with thickened mordants, then fix and dry, after which it is dyed with a mordant colour, which is in its turn again only fixed where the pattern has already been treated.

Resist printing with mordants, is done by printing the material with tartaric acid or citric acid and then drying. The mixture of mordant and mordant colour, which then first comes into action, is not fixed on the places printed by the acid. In chemical discharge work the material is first treated with a mordant and then printed with a weak acid and finally dyed. On the other hand, materials which are already dyed are discharged with oxidizing agents such as $\text{K}_2\text{Cr}_2\text{O}_7$ + H_2SO_4 , or with mixtures which liberate chlorine, &c.

Those colouring matters which are first obtained on the fibres are also important in printing or other methods.

Calico printing is the most important branch of the subject.

In wool printing the acid colours used for dyeing cotton are scarcely ever employed. Compare "ACID DYESTUFFS". They are thickened and (after mixing with the acids) printed on the wool, which must have already been subjected to the action of chlorine, and then steamed. Most of the acid colours can be discharged by reducing agents.

The printing of silk is carried out much in the same way as the printing of woollens. Besides the methods of direct printing and printing by chemical discharge, resist printing is also adopted, the silk being printed with fatty resists and then dyed.

Improvements and novelties in the branch of textile printing make their appearance every year in such numbers, that even a simple list cannot be here given. Reference can only be made to the extended use which has of late been made of hydrosulphites as discharging agents. The method of employing these substances was formerly accompanied by many difficulties, especially on account of the low degree of concentration of the available sodium hyposulphite solutions, and the ease with which they oxidize. Germ. Pat. 133178 has done away with these difficulties. According to this patent, it has been found that hydrosulphites in concentrated, as well as in solid form, more especially also as double salts of the hydrosulphurous acids, are remarkably useful agents for discharge work, on account of their stability and comparatively high degree of solubility, and the fact that by using these substance it is possible to mix a sufficient quantity of the effective material into the printing matter. In this way colours on wool, cotton and silk as well as on mixed goods can be discharged, leaving a pure white colour. The best white is obtained by the use of zinc sodium hydrosulphite, on account of the zinc hydroxide which is simultaneously precipitated on the fibre. By the addition of colours which resist hydrosulphite for making the printing mixture, coloured effects can also be produced. The method can be employed on materials dyed with azocolours, of either a substantive or acid nature, with basic colours, and with sulphonic acids of the triphenylmethane colours, as well as for such colours as are developed on the fibre. The printing paste can be made with additions of solvents such as acetone and glycerine, of alkalies, salts with alkaline reaction, albuminates or organic substances. According to Suppl. Germ. Pat. 135725, the same firm has also found that an addition of bisulphites to the printing substance is advantageous as, with this addition, colours which in general are discharged with difficulty are more readily acted upon. Compare French Pat. 297370 and three supplements. The employment of the hydrosulphites in printing is daily increasing, the hydrosulphite preparation termed hyraldite being very widely used. On this question as also on the methods of preparation, purification, and the rendering stable of hydrosulphites, see "HYDROSULPHITES". In the above named article mention is also made of those very important preparations for discharge printing, eradite and rongalite. With the enormous increase of literature on this subject, it is impossible to make a choice for quotation in this work and we can only refer the reader and student to the article by HENRI SCHMID on "Die Anwendung der haltbaren Hydrosulphite in der Druckerei", Chem.-Ztg. 1905, 609 ff.

The printing of woollens has increased considerably during the last two years, and printing by discharge with hydrosulphites is becoming still more widespread.

French Pat. 341007 protects a new printing method in which cellulose acetates which are soluble in alcohol and serve as substitutes for the thickening of fixing materials, are used in the production of patterns on textiles. Materials printed in this manner not only give more vivid tones and are more durable after washing, but are also much softer than those treated with albumen.

colours which tend to harden in consequence of the coagulation of the albumen coating.

Germ. Pat. 139217, 140602 and 141450 and also the French Pat. 338831 deal with processes for printing with indigo.

Two curious processes of printing materials founded on quite other than the usual methods, should also be here referred to. These are the so-called CADGENE sprinkling process and ROLFF's photo-mechanical printing process.

CADGENE's very interesting method is carried out by passing the material before the openings of a series of sprays. These shower pipes are fed from vessels containing coloured solutions and sprinkle the colour in the form of a fine rain on to a piece of silk. As is evident the principle is very simple, but at the same time the apparatus is capable of giving beautiful designs. For the simplest effects, the sprays are firmly fixed, when parallel coloured stripes appear, brought about by the regular movement of the material. These stripes are a deep colour in the middle and shade into delicate ombre effects. There are, however, different arrangements of the apparatus, which can be made so as to produce the most manifold variations. As the distance between the pipes can be altered at will, and as the colour solution in the single pipes can be either of different shades or colours, it is a simple matter to produce beautiful effects. The pipes can also by means of suitable mechanical arrangements be moved in horizontal, vertical, slanting, or curved movements. The currents can also be regulated so as to be periodically stronger or weaker; the stuff also can be mechanically adjusted to make periodically varied movements in different directions, with increasing or decreasing rapidity. All these variations of the method are protected by several patents. Silk materials are best adapted for printing by this process. Firstly, because the beauty and brilliancy of the colours are more effective on silk, and secondly, because this material very easily absorbs the fluid and can as easily be quickly dried, so that the finer tones of colour can be more delicately produced than on any other textile. The colours are in most cases in the form of aqueous solutions; in cases, however, of "faillie" and "surrah" silks, alcoholic solution of colour must be employed to prevent the materials losing their characteristic qualities. The material runs with a lining from the top to the bottom, is met by a coloured steam current, runs over drying apparatus (gas burners), then over dry cylinders and falls off in folds. For very thin silk materials such as pongé the process must be more rapid, while satin and silk mixtures, &c. must pass down at a slower rate. Iridescent effects, such as rainbow colours, are brought about by a crank movement of the shower pipes, so that the material is very slowly moved (4 to 5 minutes for a 60 m piece). The amount of colour required is very small and the apparatus very simple. It should be mentioned that KNAPSTEIN has lately claimed priority in the invention of this method.

ROLFF's photogravure and three-colour printing process is an important novelty in the branch of textile printing. The inventor gave a lecture at the V. International Congress for Applied Chemistry, held in Berlin in 1903. The principal difficulty is to obtain a perfectly regular coating on the rollers so as to produce the same degree of sensitiveness to light. The inventor after many experiments finally attained this result by means of spirals.

This difficulty being done away with, the inventor could follow the principle used in the printing of illustrated papers, more especially the method known as Raster printing. As is well known the principle of Raster printing is the carrying out of the design of the whole picture by a network of dots. The sensitive coating is, as a rule, made of chrome—fish glue, which has the property of becoming insoluble in water only in those places affected by the light.

A Raster film of the picture to be printed is first made and then fitted on to a copper cylinder which is coloured with sensitive coating. It is then copied, either in the sun or by electric light, and developed by rotating the cylinder in water. The chrome-glue dissolves from the unattacked parts of the cylinder, and the polished copper shows through. The coating is dried, the cylinder heated till the fish-glue is quite hard, the cylinder is etched and the preparation of the print is ready. If the pattern is to be of several colours, each single colour must be photographed on the small steel cylinder as a hard relief molette, which is then impressed on a copper printing roller. If very fine shadings are required the pattern is drawn in Indian ink, produced by the Raster on the film and further on to the molettes. The Raster gives the shades so accurately that flowers (for instance) which are otherwise required to be printed in six colours can be produced by ROLFFS' method with exactly the same effect, in three colours. The lecturer up to this point was already extremely interesting and the patterns exhibited showed what beautiful results it was possible to obtain. But the inventor had gone still farther and had attempted the most difficult task there is in the art of printing paper, that is of printing with three colours and, showed how he had also rendered this a practical possibility for the printing of cotton. As is known, three-colour printing is carried out by separating the picture by means of suitable light filters into its primary colours, yellow, blue, and red. These single parts of a picture are etched direct on to the rollers, whereby pictures and patterns can be obtained 10—20 times as quickly as formerly. Further, in every case even for the most complicated colour effects, only three rollers are required, the printing is much quicker, and there is economy of rollers, machinery, labour, and colours. Originally ROLFFS worked out his method only for the printing of cotton, but it very quickly came into vogue for wall-papers. These processes are naturally protected by Letters Patent.

MEYER has published an almost identical process for photographic printing rollers which he claims as his invention. WOLKOFF's process is somewhat different from this, the sensitive material being exposed to the light not on rollers but on flat surfaces. The chrome gelatine coating is on paper and after exposure is developed on this and then rolled off on to the cylinder.

Printing colours:

E. T. Gleitsmann, Dresden, Germany.

Printing varnish:

E. T. Gleitsmann, Dresden, Germany.

Projection.

Projection lamps:

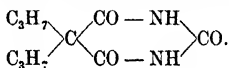
Gustav Barthel, Dresden-A. 19 (see front part advt.).

Propiolic acid. o-nitrophenylpropionic acid is known commercially by this name. Its constitution is as follows $C_6H_4(NO_2)C : C.CO_2H$. It is made by converting cinnamic acid into its ethyl ester by the action of alcohol and concentrated H_2SO_4 , and nitrating the ester with the calculated amount of nitrating acids in the cold, when approximately the same quantities of the ethyl esters of o- and p-nitrocinnamic acids are formed. The mixture is warmed with alcohol and then allowed to cool to 35—40° when the p-compound separates almost completely and the o-nitrocinnamic ester remaining in solution can be isolated by distilling off the alcohol. It is then saponified by warming with H_2SO_4 , drying the o-nitrocinnamic acid and treating it with the calculated amount of bromine. If the dibrom-derivative is allowed to stand in aqueous solution with concentrated soda lye, and the temperature is kept low, the mass solidifies to a thin paste of NaBr and the sodium salt of

o-nitrophenylpropionic acid. From this by the addition of dilute acids, the o-nitrophenylpropionic acid is obtained in small shining crystals which can be filtered off and washed. The substance comes into the market under the name of "PROPIOLIC ACID" in the form of a thin paste with 20 % dry contents. Formerly it was employed in the synthetic manufacture of indigo but is now little used. Compare also "CINNAMIC ACID".

Propionic acid. $\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}$. This acid is found as a result of the fermentation of wheat bran, and also in the dry distillation of wood. It is therefore present in crude wood vinegar. It is usually made by the oxidation of normal propyl alcohol (q. v.) with CrO_3 . It forms a colourless very acid liquid which has a strong smell of vinegar. It can be mixed with H_2O , alcohol, and ether. S. G. 0.992 at 18° , B. P. 140° . Its salts are crystalline and completely soluble in H_2O . Its esters have a fruity smell and are used as fruit essences (q. v.).

Propional (dipropylbarbituric acid; dipropylmalonylurea).



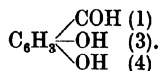
A colourless, crystalline substance with a slightly bitter taste. M. P. 145° . Sparingly soluble in cold, more readily in hot water. Very soluble in dilute alcohol. It is used as a soporific and has a stronger and better action than the chemically allied veronal. For its preparation see Germ. Pat. 146496.

Propyl alcohol. $\text{C}_3\text{H}_7 \cdot \text{OH}$. A distinction must be made in the first place between the normal or primary propyl alcohol, ethylcarbinol, $\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{OH}$, and between secondary propyl alcohol, isopropyl alcohol, dimethylcarbinol $(\text{CH}_3)_2 \cdot \text{CH} \cdot \text{OH}$. Only the normal propylalcohol is of technical importance. It is found in crude spirits, amyl alcohol and in grape fusel oil. It is extracted either by fractionation, or it is made absolutely pure from propyl bromide. It is a liquid, with a pleasant alcoholic smell; it is miscible with water in all proportions and is inflammable. S. G. 0.8066 at 15° ; B. P. 97.4° . It does not dissolve in a cold saturated solution of CaCl_2 as ethyl alcohol does.

Protalbinic acid and lysalbinic acid. These are the names given to the decomposition products obtained by the alkaline hydrolysis of albumen. The soluble alkali salts of these acids are formed (Germ. Pat. 129031) when albumen is subjected to alkaline hydrolysis. The products are separated by acidifying and filtering. The protalbinic acid which remains on the filter is dissolved in excess of alkali, and the solution containing lysalbinic acid is also treated with excess of alkali. The solutions are dialysed until the water has a neutral reaction and contains no more mineral salts; it is then carefully evaporated to dryness. The alkaline hydrolysis is carried out according to one method by adding 100 parts of albumen to a solution of 15 parts of NaOH in 500 parts of H_2O , stirring and warming on the water-bath with addition of water to replace that lost by evaporation. The albumen, except for a little flaky deposit, dissolves completely. The liquid thus obtained is filtered and after cooling HNO_3 is added till no more precipitate of protalbinic acid is formed. The rest of the process is described above. The alkaline salts of protalbinic acid and lysalbinic acid liberate the heavy metals in a colloidal form from their salts (Ag, Hg and Au). Compare "COLLOIDAL SUBSTANCES". MOEHLAU has also succeeded in bringing indigo into solution in the same way. See "INDIGO DYE STUFFS".

Protargol. A compound of silver and albumen. It is a dusty, pale yellow powder containing 3.8 % of Ag in organic combination. It is soluble in water to the extent of 50 %. Protargol is used medicinally as an antiseptic dressing for wounds and also in gonorrhoea.

Protocatechuic aldehyde.



This compound is important since it serves as the starting point for the manufacture of vanilline (q. v.). According to Germ. Pat. 162822 it may be prepared by treating piperonal (q. v.) with dilute acids or acid salts (e. g. bisulphites) under a pressure of 12 atmospheres at a temperature not above 190°.

For its preparation from piperonal, see also Germ. Pat. 165727 and 166358. The latter is a supplement to Germ. Pat. 162822.

Provence oil see "OLIVE OIL".

Pseudoionone see "IONONE".

Pseudocumene see "CUMENE".

Psoridian. A rose-coloured ointment obtained by the action of margaric acid on yellow mercuric oxide. It has a pleasant smell and is used as a salve in various diseases of the skin.

Pulverizers.

Pulverizers:

John Davis & Son (Derby) Ltd, Derby.

W. Stamm, 26 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Pumice stone. A volcanic mineral consisting principally of aluminium silicate. It is found in the neighbourhood of volcanoes, extinct and active. Pumice stone is a sponge-like substances, full of bubbles and often mixed with fibrous material; the colour is white, grey, brownish-grey or yellow. S. G. 2.19 to 2.2. It is used as a polishing powder, for making water filters, and in the manufacture of a certain kind of soap.

Artificial pumice stone is also found on the market in the form of bricks or cakes. This variety is made by compressing pumice stone powder and some adhesive into the desired shape; it is for some purposes preferable to the natural stone. According to Germ. Pat. 146688, a material similar to pumice stone is made by boiling other silicates, besides pumice stone, which can be disintegrated by acids or alkalies, with dilute alkaline solutions to form a thick paste, and then quickly expelling the water by a rapid increase of temperature. The materials best suited for this purpose are natural and artificial aluminates, which are decomposed by boiling. The sudden expulsion of the water causes the mass to assume a porous structure.

Pumps.

Pumps:

C. Harzer & Co., Finsbury Pavement House London E.C.
Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Earthenware pumps:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Pumps of metal and cast iron:

Volkmar Haenig & Comp., Heldenau-Dresden, Germany (see front part advt.).
Friedrich Heckmaun, Berlin SO. 16, Brückenstr. 6b (see advts).

Purgatine (trioxydiacetylthraquinone). This substance is used as an aperient.

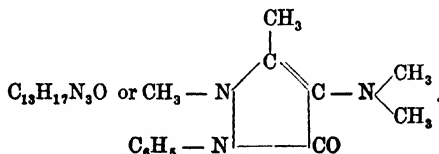
Purree (Indian yellow). A dyestuff obtained in India and China from the urine of cows fed upon mango leaves. The colouring matter of the bile becomes yellow through this feeding.

The essential constituent of the substance is the magnesium salt of euxanthic acid. It is used for the preparation of an artist's colour (Indian yellow).

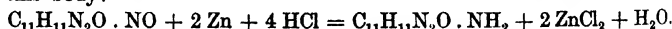
Pyoctanine. By this term is understood two different coal-tar colours used in medicine, yellow pyoctanine (*pyoctaninum aureum*), which is auramine, and blue pyoctanine (*pyoctaninum coeruleum*) or methyl violet.

Both these preparations, particularly the blue variety, are used in surgery as bactericides, in cases of boils, &c. These preparations are also used in veterinary practice as specific remedies in cases of foot and mouth disease.

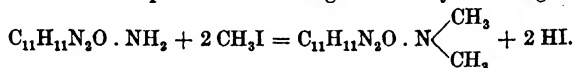
Pyramidone = Dimethylamidoantipyrene (Phenyldimethyldimethylamido-pyrazolone).



In order to prepare this substance (Germ. Pat. 71261) antipyrene is converted into a nitroso derivative. Amidoantipyrene is obtained by the reduction of this body:—



This amidocompound on treating with alkylhalides gives pyramidone



It forms small colourless crystals, M. P. 106—107°, soluble in water, more readily in warm water, very readily in alcohol and benzene. It is used as an antipyretic in place of antipyrene. Dose 0.1 to 0.5 g.

The salicylate and camphorate are also important.

Pyrazoline = Antipyrene (q. v.).

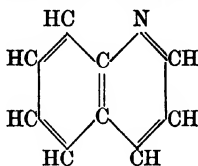
Pyrazolone dyestuffs see "TARTRAZINE".

Pyridine and quinoline. The pyridine bases correspond to the general formula $\text{C}_n\text{H}_{2n-5}\text{N}$. Pyridine, $\text{C}_5\text{H}_5\text{N}$ is the parent substance; it is regarded as benzene in which 1 CH group is replaced by N. It is isolated from coal tar and bone oil. The latter is warmed with dilute H_2SO_4 , the filtered solution precipitated with NaOH and the free bases fractionated. It is obtained from coal-tar directly from the washings of the light oils which contain a large quantity of pyridine. The process is the same as given above, the wash-water is decomposed with soda lye and the bases which separate are distilled. Sometimes, however, these bases must be again dissolved in H_2SO_4 and precipitated

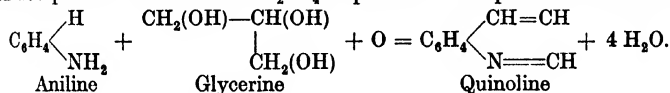
with NaOH after which the product is fractionated. Recently some pyridine has been successfully prepared from brown-coal-tar.

Pyridine is a colourless fluid, which mixes with H_2O and has an intense characteristic smell. S. G. at 0° 0.9802; B. P. 115° . It serves for denaturing spirits and is used as a remedy for asthma. According to Germ. Pat. 134139 it is employed for purifying synthetic indigo; and also (Germ. Pat. 139669) for the manufacture of cellulose esters. Several derivatives are also obtained from this substance. Homologous with pyridine are picoline C_6H_7N , lutidine C_8H_9N , collidine $C_8H_{11}N$ and others.

The quinoline bases correspond to the general formula $C_nH_{2n-11}N$. The original substance quinoline C_9H_7N stands in relation to pyridine as naphthalene to benzene. Quinoline possesses the following constitution:—



It is formed during the dry distillation of nitrogenous organic compounds and is found in coal-tar and brown coal-tar. The preparation by the SKRAUP synthesis is interesting. 28 parts of aniline are heated with 120 parts of glycerine and 100 parts of concentrated H_2SO_4 in presence of 24 parts of nitrobenzene.



The nitrobenzene is here simply the oxidizing agent and may be replaced by As_2O_5 .

Quinoline is a colourless very refractive liquid with an intense characteristic smell. S. G. at 0° 1.1055; B. P. 236° . It is used as a medicine, and for the manufacture of colours.

Pyrocatechine, o-dioxybenzene. $C_6H_4(OH)_2$. This substance is formed during the dry distillation of wood and from some resins by melting with caustic potash. It is also present in raw beet sugar. It was first made by the dry distillation of catechu, and it can be obtained by fusing many resins with KOH. Further it can be obtained from its monomethylester, guaiacol, by heating this substance with HI to 200° . It is now prepared almost entirely by synthetic methods from o-chlorophenol, o-iodophenol, o-bromophenol, or from o-phenolsulphonic acid and KOH. Germ. Pat. 141751 is of importance as regards the synthetic preparation of this substance. The process is materially simplified. Phenol is sulphonated giving phenol p-sulphonic acid, converted into o-chlorophenol p-sulphonic acid with cooling, and the SO_4 is separated from this by heating to $180-200^\circ$. The o-chlorophenol thus formed is then purified by steam distillation.

A quite new process is the preparation of pyrocatechine from beech-wood-tar, in which it is present in small quantities. It has also been found in the ammonia water of coal distillation.

It is a white crystalline substance, which has a bitter taste, and can be sublimed. It dissolves readily in water, alcohol, and ether, and has the properties of a reducing agent. M. P. 104° ; B. P. $240-245^\circ$.

Pyrogallol (pyrogallie acid), 1 : 2 : 3 trioxybenzene. It is obtained by heating gallic acid and is usually prepared from this source. Gallic acid

is heated in autoclaves to 200—210° with 2—3 times the amount of water, the cold solution, is decolourized with animal charcoal, filtered, evaporated, and allowed to crystallize. The pyrogallol is purified by sublimation. It may also be obtained by distilling a mixture of 1 part of gallic acid with 2 parts of coarsely powdered pumice stone in a current of CO₂.

White shining crystals (leaves or needles) which are poisonous and have a bitter taste. M. P. 131°, B. P. 210°. It sublimes without decomposition. It dissolves in 1.7 parts of water or ether and in 1 part of alcohol. Alkaline solutions readily absorb oxygen from the air, at the same time turning brown. Aqueous solutions are turned blue by freshly prepared FeSO₄ solution, brownish-red by Fe₂Cl₆ and black by AgNO₃ solution. It has a strong reducing action, is used in photography, electro-plating and medicine, as a hair-dye and for the estimation of oxygen.

The presence of gallic acid may be recognized by dissolving 2 g pyrogallol in 5 ccm ether (S. G. 0.72). If more than 0.1 % gallic acid is present the solution remains cloudy or a small crystalline residue is left.

Pyroleic apparatus see "FATTY ACID APPARATUS".

Pyroligneous acid. A product of the dry distillation of wood (see CHARCOAL BURNING). The crude reddish-brown or reddish-yellow acid is worked up by two different methods. The one process consists in filtering through linen and wood charcoal, allowing to stand for at least a week and then separating the crude product into methyl alcohol and pyroligneous acid by fractional distillation.

The other process, for the manufacture of pure acetic acid, is as follows:— The crude acid is neutralized with lime or sodium carbonate and allowed to stand for several days. The calcium or sodium acetate is then distilled with H₂SO₄ (compare ACETIC ACID).

Pyroligneous acid apparatus:

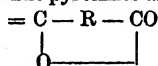
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Pyrometers.

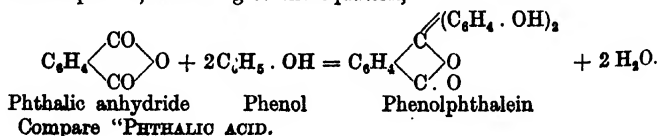
Pyrometers:

W. Niehls, Berlin SW. 48.

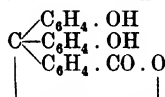
Pyronine dyestuffs. To this group belong the phthaleines, eosine and rhodamine and the pyronines proper. The pyronines are characterized by the group



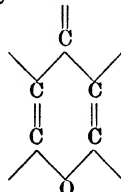
in which both C atoms are attached to 2 neighbouring carbon atoms of the phenylene (ethylene) group in the orthoposition to each other. Such compounds are obtained by the condensation of 1 molecule of phthalic anhydride, or succinic anhydride, with 2 molecules of a phenol (monoxy or higher phenol), or a m-amidophenol, the condensation being carried out in most cases in the presence of a dehydrating agent, such as SnCl₄ or concentrated H₂SO₄. In this way phenolphthalein is produced from phthalic anhydride and 2 molecules of phenol, according to the equation,



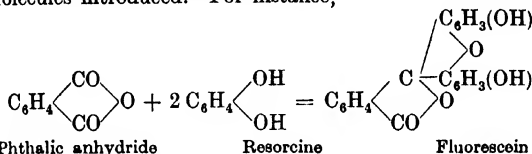
The constitution of phenolphthalein is often written,



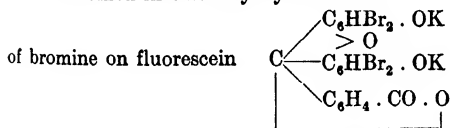
Only those phthaleines are dyestuffs in which the ring:



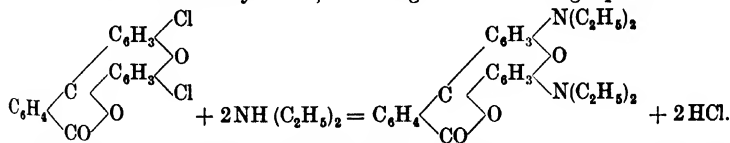
is present. This is due to the further anhydride formation between the two phenol molecules introduced. For instance,



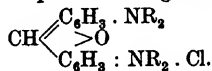
Resorcin itself is not a dyestuff except in the form of its salts and esters. The eosines which are formed by the introduction of halogen atoms or nitro-groups into the resorcin portion of fluorescein are of more importance. The alkali salts of the tetra-brom-fluorescein, known under the name of eosin is formed in this way by the action



If instead of resorcin, m-amidophenol and its alkyl derivatives are condensed with phthalic anhydride, rhodamines are formed. These can also be obtained by the treatment of fluorescein with NH_3 or dialkyl amine. Rhodamine B, diethylmetamidophenolphthalein hydrochloride, is obtained from fluorescein chloride and diethylamine, according to the following equation:—



Finally the pyronines are obtained from m-amidophenols by the action of methylchlorides, methylbromides, acetaldehyde, paraldehyde, formic acid and formaldehyde. They correspond to the general formula



The eosines and rhodamines are thus classed with the triphenylmethane colouring matters, while the pyronines are derived from the diphenylmethanes.

Q

Quartz (silicic acid anhydride). SiO_2 . It is found crystalline, transparent and colourless as rock crystal, coloured light yellow as citrine, violet (with Mn) as amethyst, brown to black (with bituminous admixtures) as smoky topaz, opaque grey or yellowish as common quartz, milky white as milk-quartz, pink as rose-quartz. Quartz is an essential constituent of many rocks (granite, syenite and gneiss); SiO_2 itself, forms the rocks quartzite, siliceous schist, sand, and sandstone; the last-named consists of quartz granules cemented together. Quartz schist is used as a substitute for fire clay, while ground quartzite is used in steel casting.

Quartz glass. After many attempts to obtain fused silica in a useful form HERAEUS, of Hanau, has succeeded in producing large quantities. The rock-crystal is fused in an iridium furnace heated with a large oxy-hydrogen flame. Only pure iridium vessels can be used, as quartz does not fuse below 1700°C ; the temperature in the vessels may not rise above 2000°C as then the Ir also melts.

In manufacturing quartz glass the crystals are broken up into small pieces and heated to 1000° and then quickly placed into cold water; by repeating this process several times the coefficient of expansion is very much reduced. According to Germ. Pat. 157464 a quartz glass of the same properties can be produced not only from rock crystal but also from quartz sand, siliceous earth, &c. The raw material is fused to a compact mass which is cooled, broken into small pieces and treated exactly like the crystals.

Many kinds of vessels are made of quartz glass, and these possess various advantages over those made of ordinary glass. They may be exposed to very high temperatures without softening and are absolutely indifferent to changes of temperature, so that for instance cold water may be poured into a small white-hot retort without breaking it. As the coefficient of expansion of quartz glass is only $\frac{1}{17}$ of that of platinum it is a very suitable material for standard thermometers. The drawback to these advantages is that quartz glass at high temperatures is very sensitive to the action of all oxides. Quite small amounts of alkali attack it, e. g. even the amount deposited by touching with a slightly perspiring hand. Quartz glass which is to be strongly heated must be thoroughly cleaned and not touched again. On the other hand metals free from oxides have no action upon it, so that it may be used in melting metals and even for their fractional distillation; e. g. the silver always present in gold may be distilled off.

As quartz glass can only be made in vessels made of the expensive metal iridium, and as much oxygen is used in fusing and working it, and as none but the most skilled workers are able to work quartz glass into vessels the prices of utensils are very high. Nevertheless for many purposes they are very valuable. For commercial purposes a cheaper product has been introduced by Messrs JOHNSON MATHEY & Co. of London. The surface is rough and it is not transparent but milky white.

It is now possible to obtain in quartz glass not only all forms of apparatus that can be produced in ordinary glass, but also apparatus from designs which would present insuperable difficulties to workers of ordinary glass. As regards the commercial aspect, prices are necessarily higher than those of ordinary glass in so far as the simpler forms of apparatus are concerned, although the reliability of quartz glass has proved it to be more economical for laboratory use where the usual care in handling glass is observed. In the case of the more intricate designs the disparity in price between quartz

glass and ordinary glass decreases, and in many such cases the cost of working the latter would be actually greater.

Quartz glass. Silica fused transparent glass apparatus:

Johnson, Matthey & Co. Ld., 74—81 Hatton Garden, London E. C. (Descriptive price lists can be obtained.)

Quinine and other cinchona alkaloids. These highly important alkaloids are contained in the *Cortex Chinae*. Quinine bark is obtained from different kinds of *Cinchona*. The alkaloids are separated from the bark by grinding the material with lime in a fine mill, and then extracting with warm mineral oils which have a high boiling point, such as paraffin. The alkaloids are then separated from the solution by shaking with dilute H_2SO_4 . After this follows the separation of the different cinchona alkaloids from each other. The following alkaloids are present in the acid solution, the proportions varying according to the bark used.

Quinine $\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2$; hydroquinine $\text{C}_{20}\text{H}_{26}\text{N}_2\text{O}_2$; cinchonidine $\text{C}_{19}\text{H}_{22}\text{N}_2\text{O}$; hydrocinchonidine $\text{C}_{19}\text{H}_{24}\text{N}_2\text{O}$; quinidine $\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2$; hydroquinidine $\text{C}_{20}\text{H}_{26}\text{N}_2\text{O}_2$; cinchonine $\text{C}_{19}\text{H}_{22}\text{N}_2\text{O}$; cinchotine $\text{C}_{19}\text{H}_{24}\text{N}_2\text{O}$ and others.

The hot sulphuric acid solution of the alkaloids is neutralized with Na_2CO_3 . The greater part of the quinine crystallizes on cooling as an impure sulphate. The three most important alkaloids are QUININE, QUINIDINE and QUINIDINE.

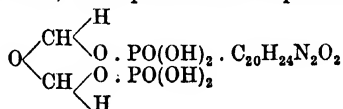
QUININE. The anhydrous base has the formula $\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2$. It also crystallizes with $3\text{H}_2\text{O}$. The substance is purified by secret methods. Use is made of the fact that quinine is precipitated by ROCHELLE salt as an almost insoluble tartrate. The base is precipitated from the quinine sulphate by NH_3 , and forms a white crystalline odourless and very bitter powder, which dissolves readily in alcohol and chloroform, but with difficulty in water. The pure sulphate of quinine $(\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2)_2 \cdot \text{H}_2\text{SO}_4 + 8\text{H}_2\text{O}$ forms loose, white, silky, crystalline needles. It has no smell but has a lasting bitter taste, and dissolves far more readily in H_2O , especially hot water, than the free base.

QUINIDINE is a cinchona alkaloid which does not crystallize. It is made by precipitating the mother liquors from the manufacture of quinine, from which as much as possible of the crystalline alkaloids has been separated, with caustic soda, and kneading the resin-like product with H_2O to purify it. It forms a resinous mass of a brown to brownish black colour, which is very brittle, almost insoluble in water, and which represents a mixture of different amorphous cinchona alkaloids.

QUINIDINE. $\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2$. An alkaloid isomeric with quinine, usually made from quinidine. The latter substance is treated with ether; the ether is then allowed to evaporate from the extract, and the residue dissolved in dilute H_2SO_4 , accurately neutralized with NH_3 , and precipitated with a concentrated solution of ROCHELLE salts when the tartrates of the quinine and cinchonidine are precipitated. After this is filtered off, the tartrate is decolourized with animal charcoal and the quinidine is precipitated with KI solution as quinidine-iodide. The anhydrous base forms crystals M. P. 168° . They dissolve readily in alcohol and ether, but with difficulty in H_2O . The salts are usually used for medicinal purposes.

Quinum lygosinatum, see under "LYGOSINE PREPARATIONS".

Quinine phytine. Obtained by neutralizing phytine (anhydrooxymethylene-diphosphoric acid) with quinine and evaporating *in vacuo*. The formula is

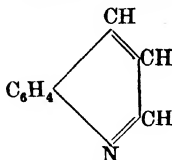


A yellowish crystalline powder with a bitter taste; very soluble in water, insoluble in alcohol, ether, C_6H_6 and $CHCl_3$. It contains 57 % quinine. It is prescribed for headaches, neuralgia, and malaria.

Quinoformine. A compound of quinic acid and hexamethylenetetramine (urotropine). Used medicinally as a solvent for uric acid.

Quinoline, see "PYRIDINE AND QUINOLINE".

Quinoline dyestuffs. In this group of dyestuffs the quinoline nucleus



seems to play the part of a chromophore.

Included in this group are the cyanines obtained by heating a mixture of quinoline and p-methylquinoline (lepidine) with an alkyl iodide in the presence of alkali. The blue dyestuff contains two molecules of the alkyl group and 1 molecule of each base. Quinoline blue is obtained by the action of amyliodide and KOH on a mixture of equivalent quantities of quinoline and lepidine. Quinoline yellow (quinophthalone), soluble in spirit, is the condensation product of molecular proportions of quinaldine (methylquinoline) and phthalic anhydride.

Quinones. Diketones obtained by the substitution of 2 atoms of H by 2 atoms of oxygen in the benzene nucleus. The oxygen atoms are in the para position.

QUINONE. $C_6H_4O_2$. In order to prepare quinone, a cooled solution of 1 part aniline, 8 parts H_2SO_4 in 30 parts water is treated gradually with 3.5 parts $K_2Cr_2O_7$. After standing for some time the mixture is warmed to 35° , the quinone extracted with ether and purified by recrystallizing from ligroin solution.

Yellow prisms or needles with a penetrating smell resembling that of chlorine. M. P. 115.7° . It is sparingly soluble in cold, readily in hot water, alcohol and boiling ligroin.

CHLORANIL (tetrachlorquinone). $C_6Cl_4O_2$. Obtained on a large scale by oxidizing trichlorophenol with $K_2Cr_2O_7$ and H_2SO_4 . According to WITT it may be obtained in the following way:— p-nitraniline is treated with $KClO_3$ and HCl; sym. 1, 2, 6, 4 dichloronitraniline is formed which is reduced by Sn and HCl to dichlor-phenylenediamine and this substance treated at boiling temperature with $KClO_3$ and HCl.

Golden yellow crystals which do not melt but sublime without decomposition. Insoluble in water, sparingly soluble in alcohol, more readily in ether. It is used in the preparation of certain dyestuffs.

For hydroquinone and anthraquinone see special articles.

Quinone imide dyestuffs. Derived from the as yet unknown imides of quinone and its homologues. They include the indamines, indophenols, oxazines, thiazines, azine dyestuffs, safranines and indulines.

The chromophore group is either $O = R = N - R'$ or $- N = R = N - R$.

Quinoneoxime dyestuffs, see "NITROSO DYESTUFFS".

Quinonephthalone, see "QUINOLINE DYESTUFFS".

Quinosol. Potassium salt of oxyquinolinesulphonic acid $C_9H_6 \cdot NO \cdot SO_3K$ containing 1 or $\frac{1}{2}$ molecule of H_2O . According to Germ. Pat. 88520 it is obtained by boiling o-oxyquinoline with an alcoholic solution of potassium pyrosulphate.

Yellow, crystalline powder, easily soluble in water, with a saffron-like odour. A valuable antiseptic with a stronger action than corrosive sublimate. This strength of action is due to the fact that it penetrates further into the tissues and does not precipitate proteids. It is not corrosive and practically non-poisonous. It is used for disinfecting the hands (1 : 1000) and for wounds (1 : 500). It is also used as a 2 % powder for wounds.

Quinotropine. A compound of urotropine. Crystals M. P. 118—125° with a pleasant acid taste. Readily soluble in water, less so in alcohol. On account of its solvent action on uric acid it is prescribed in gout. 2.5—3 g per diem in 2 or 3 doses, each dissolved in 500 ccm water.

Quinoxaline dyestuffs, see "AZINE DYESTUFFS".

R

Radio-active substances. This name is given to a series of substances which have the property of emitting rays resembling cathode- and ROENTGEN rays. A distinction is made between true and induced radio-activity; the latter occurs with the former in nature, and may also be produced artificially by contact or electric influence.

The phenomenon of radio-activity was first observed in uranium, though several facts led to the conclusion that the rays were not due to uranium itself but to some unknown substance. The radio-active agent was named RADIUM, and was obtained as RADIUM-BARIUM when the barium was separated from pitch blende and the residues from uranium extraction. The various radium-barium salts at first possess (after crystallization or precipitation) but little radio-activity; it rises, however, in the course of a few weeks to a constant maximum. Apart from the active properties, radium-barium salts resemble barium salts from a physical and chemical point of view. — Radio-lead has also been obtained by separating lead from uranium pitch blende, uranium mica and other uranium minerals by the usual analytical methods. These radio-lead salts, apart from their activity, are in no way different from pure lead salts.

The new element RADIUM (Ra), A. W. 225, is similar to barium; it colours the flame red, its salts possess a characteristic spectrum and are phosphorescent. The evolution of gas from solid salts and their solutions is very remarkable (see Ber. Deutsch. Chem. Ges. 35, 3608 and Chem. Zeitschr. II, 396).

The discoverers of radium, P. and Sk. CURIE prepared a highly active bismuth from the pitch blende, and ascribed the activity to a new element POLONIUM, mixed with the bismuth. The preparation of polonium-bismuth is done in the usual analytical way. The elementary character of polonium has not yet been established. According to experiments of MARCKWALD a small clean rod of bismuth dipped into a solution of active bismuth chloride will cause the radio-active substance to settle on its surface.

Finally it should be noticed that THORIUM separated from thorium ores containing uranium possesses radio-active properties. These properties have

been ascribed to an element ACTINIUM, and active thorium is called THORIUM-ACTINIUM. Radio-active tellurium has also been discovered.

According to E. DUBOIS the radio-activity of the better known radio-active substances (minerals) is as follows:— the radio-activity of uranium being reckoned as unity:

Pitch blende (Johanngeorgenstadt).....	3.6
Pitch blende (Joachimsthal).....	3
Various thorites	0.04—0.06
Orangite	0.9
Carnotite	2.7
Autunite	1.2
Chalcolite	2.3
Cleveite	0.6
Monazite	0.2
Fergusonite	0.04—0.2
Samarskite	0.5
Niobite	0.04 .0.12
Tantalite	0.01

In her book on radioactive substances Madame CURIE gives the following directions for obtaining radium from Joachimsthal pitch blende:

The mineral is crushed and roasted with Na_2CO_3 and the product extracted with H_2O and dilute H_2SO_4 . The solution contains the uranium, the residue the radio-active substances. This residue has four and a half times the radio-activity of metallic uranium and consists mainly of the sulphates of lead and calcium, with silicon, alumina and iron oxide. Besides this nearly all metals are present in greater or less amount (copper, bismuth, zinc, cobalt, manganese, nickel, vanadium, antimony, thallium, the rare earths, niobium, tantalum, arsenic, barium, &c.). Radium sulphate is the least soluble. In order to dissolve it the H_2SO_4 must be removed as completely as possible. The residue is therefore treated with concentrated boiling caustic soda. The H_2SO_4 combined with the lead, aluminium and calcium is for the greater part dissolved as Na_2SO_4 and is removed by washing with H_2O . The alkali at the same time removes Pb, Si and Al. The insoluble portion is then washed with H_2O and treated with HCl. The substance is now porous and the greater part dissolves. Polonium and actinium may be separated from this solution. The former is precipitated with H_2S ; the latter is in the hydroxides which are precipitated by NH_3 after the solution is oxidized and freed from the sulphates. The radium is in the insoluble part, which is now washed with H_2O and then treated with concentrated boiling Na_2CO_3 -solution. If small traces of unchanged sulphates have been left the last mentioned operation will completely convert the barium sulphate into carbonate. The substance is then thoroughly washed with H_2O and treated with pure HCl (free from H_2SO_4). The solution which contains the radium as well as the polonium and actinium is filtered and precipitated with H_2SO_4 . Crude BaSO_4 containing radium, Ca, Pb, and Fe, also a little actinium and polonium is obtained, which may be separated in the same way as from the first hydrochloric acid solution. One ton of residue yields 10—20 kg of crude sulphates, the activity of which is 30 to 60 times greater than that of metallic uranium. The next step is the purification of the sulphates: They are boiled in Na_2CO_3 -solution and the carbonates obtained are converted into chlorides. The solution is treated with H_2S and a small amount of active sulphides containing polonium is precipitated. The solution is filtered, oxidized with Cl and precipitated with NH_3 . The precipitated oxides and hydroxides are strongly active, the activity being due to actinium. The filtered solution is precipitated with Na_2CO_3 ; the precipitated carbonates are washed and converted into chlorides. The

solution of these chlorides is evaporated to dryness and washed with concentrated HCl; the CaCl_2 dissolves almost completely while the BaCl_2 containing the radium remains undissolved. Thus one ton of material yields 8 kg of BaCl_2 containing radium. The activity is about 60 times that of metallic uranium. The further separation of barium chloride and radium chloride is effected by fractional crystallization; BaCl_2 is more readily soluble in H_2O than RaCl_2 .

The rays emitted by radio-active substances were originally called RADIUM rays or BECQUEREL rays, after H. BECQUEREL who published the first communications concerning them. At present radium rays are divided into three classes, of which the α - and β -rays can be deflected magnetically and electrically, while this is not the case with γ rays. The effects of the latter are quite like those of the ROENTGEN rays. The positively charged γ -rays correspond to the so-called CANAL RAYS of a CROOKES' tube, the negatively charged β -rays to the cathode rays of a CROOKES' tube. The α rays are regarded as ejected particles.

Most phenomena observed with radium preparations can be compared with cathode- and ROENTGEN-rays: All radium compounds emit light; screens of barium platinocyanide become phosphorescent and photographic plates are affected. They have a strong action on the skin, causing a kind of burn; this property makes radium salts dangerous poisons, though it also opens out an extensive field for medical application. An inexplicable fact is that radium continually emits energy in the form of heat.

Radium has the property of transferring activity to other substances, a phenomenon called, as remarked above, induction of activity. For this reason the actual bearer of the activity is thought to be a gas which according to RUTHERFORD's suggestion is called *emanation*. Of great interest is the fact discovered by Sir W. RAMSAY and F. SODDY and verified by most careful experiments, that this emanation contains helium, in other words that helium is formed from radium. This phenomenon which affects the foundations of chemical theory is still an unexplained mystery.

It should be added that recently radio-active phenomena have been observed in many other substances. Many springs for instance contain radium, so that various investigators are inclined to put this fact down as the reason of their medical value. The air also contains radium and it appears certain that the electrical conductivity of air depends on the amount of radium emanation present.

Ramie. The bast fibres of various kinds of nettles (*Urticaceae*), particularly of *Urtica* (*Boehmeria*) *nivea*, indigenous to China, Japan, and India. The bast is separated from the wood after harvest without previous retting. The fibres which are 22 cm long and 0.55 mm in thickness are used for making sail cloth because of their great durability. Before spinning the fibres must be softened with caustic soda and oil.

Rapidine. A product of the distillation of mineral oil. The B. P. of the fractions lie between 100° and 250° . It is chemically purified and strengthened by the addition of benzene so that it may be used for internal combustion engines.

It is clear like water, odourless and tasteless. S. G. 0.750—0.800, $290-300^\circ$ develop 1 H. P.-hour. The products of combustion are colourless, odourless and free from acid.

On account of these properties it is a serious rival of benzine and should have a future before it.

Reaction towers, absorption and condensing towers. Serve in chemical industry for the alternating action of liquids and gases on each other. These

actions of gases on fluids or fluids on gas may be for the purpose of drying and purifying the gas, as for instance in the case of chlorine or sulphuric acid gases; or for the purification of furnace gases from pyrites, the air from nitration works, &c.; or for the absorption of acid gases by liquids, such as hydrochloric, sulphuric or nitric acid gas in water, and more especially for the regeneration of nitrous fumes from nitrating and oxidizing processes. All the towers used for acids are made of earthenware and consist of the tower itself and its filling. In principle the tower is always so constructed that several cylinders are placed on a closed base fitted with supports to admit gas, and a cock for the escape of acids. The last of the cylinders also has a support joint to prevent the gas from escaping, while at the same time they give free admittance to the liquid. Above the cover is an apparatus for distributing the acid from the central pipes so that it flows over 8, 12, 24, 36 or 48 spouts.

The filling of a reaction tower varies according to circumstances. The cheapest filling is coke, but this is only used in cases where no acid such as nitric acid, which would attack the coke, is present. A disadvantage of coke filling is that it gradually decomposes and forms channels which disturb the equal distribution of the gases. Clay fillings for these towers are often used and of this material there are two distinct forms, known as the dimensional and the loose fillings. Loose fillings are such as are built into the tower without special regard to its measurements. To this class belong the pipings used in some cases, double sides, thus offering a larger surface for the gas, cones with a top piece and a hollow bottom, (used especially for purification and reaction towers proper), solid cones for cases where the principal object is to retain heat; hollow cones, employed where the filling must be as light as possible, and where a strong draught is necessary, and finally dish-shaped vessels with channels (3—6) by means of which the liquid may fall into the next below.

The plate fillings of various systems employed in the so-called plate towers are known as dimensional fillings. LUNGE-ROHRMANN's system consists of an extremely fine network of ribs and cross pieces perforated with holes for the passage of liquid and gas, which are in this way divided and then again mixed between the plates. The KYPKE star plates are filled with ribs, grooves and basins, arranged in slanting position. Through these plates the gases rise, and the acids trickle in broad zigzags always in contact with the gas. This kind of cone is much used where it is important that the draught should be very weak, as in this respect they have advantages over other kinds of fillings. Further, to this class belong the cascade basins, which have now been improved and are known under the name of Aegir plates. These plates are laid to the right and left so that the bottom is not quite covered, thus forcing the gas to take a zigzag course through the tower, while the liquid drops from basin to basin. In this system a very large surface in a given space is secured. Mention should also be made of GLOCK's bars, clay rods which are packed crossways close together so that the falling liquid drops in the form of a broad band; the surface offered to the gas is continually changed and renewed.

There are several new suggestions for the fillings of towers, but few have as yet been practically carried out.

As a rule the towers are supplied with a diameter of 500—1200 mm. The height depends on the number of cylinders which are arranged above each other.

Earthenware Reaction towers:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Esckirchen, Rheinland (Germany) (see front part advt. p.).

Reagents. Only the most important are here mentioned.

1. ACETIC ACID. $C_2H_4O_2$. 50 % acid (S. G. 1.06) is generally used.
2. AMMONIA. NH_3 . A 10 % solution is usually employed (S. G. 0.96) but sometimes a conc. solution is used (S. G. 0.91).
3. AMMONIUM CARBONATE. $(NH_4)_2CO_3$. 1 part comml. salt, 3 parts water and 1 part NH_3 (S. G. 0.96).
4. AMMONIUM CHLORIDE. NH_4Cl . Solution 1 : 9.
5. AMMONIUM CITRATE. $C_3H_4(OH)(CO_2.NH_4)_3$. 300 g citric acid are dissolved in 400 ccm water and the solution gradually neutralized with 325 g of finely powdered comml. ammonium carbonate. After standing for some hours the solution is diluted to 1.5 litre (S. G. 1.105).
6. AMMONIUM MOLYBDATE. $(NH_4)_6Mo_7O_{24}.4H_2O$. 150 g crystalline salt are dissolved in 1 litre H_2O , and the solution poured into 1 litre conc. HNO_3 (S. G. 1.2).
7. AMMONIUM OXALATE. $(NH_4)_2C_2O_4$. Strong solution 1 : 10; dilute solution 1 : 24.
8. AMMONIUM SULPHIDE. $(NH_4)_2S$. H_2S is passed into NH_3 solution until saturated, and the same volume of NH_3 solution added. If powdered S be digested with colourless ammonium sulphide the yellow ammonium polysulphide is obtained.
9. ANILINE SULPHATE. 1 % aqueous solution, or 10 drops of aniline in 50 ccm diluted H_2SO_4 (1 : 6).
10. AQUA REGIA. 3 parts HCl (S. G. 1.12) and 1 part HNO_3 (S. G. 1.20). Should be freshly prepared.
11. BARFOED'S REAGENT. 1 part copper acetate dissolved in 15 parts water; to 200 ccm of this solution 5 ccm of 68 % acetic acid are added. Used for the detection of dextrine and glucose.
12. BARIUM CHLORIDE. $BaCl_2.2H_2O$. Solution 1 : 10.
13. BARIUM HYDROXIDE. $Ba(OH)_2.8H_2O$. Solution 1 : 20 (baryta water).
14. BARIUM NITRATE. $Ba(NO_3)_2$. Solution 1 : 14 or 1 : 20.
15. BAUDOUIN'S TEST FOR SESAME OIL. Used for detecting sesame oil in margarine. (10 % of this oil must be added to margarine according to German law.)
5 ccm of the melted fat are vigorously shaken for $\frac{1}{2}$ to 1 minute with 0.1 ccm of furfural solution (1 vol. colourless furfural in 100 vol. absol. alcohol) and 10 ccm HCl (S. G. 1.19). The clear red colour of the HCl which separates below the fat shows the presence of sesame oil. In case dyestuffs are present which would colour the HCl , the fat must be previously well shaken with conc. HCl .
16. BECHI TEST FOR COTTONSEED OIL. The test depends upon the reducing action which certain constituents of the oil exert upon $AgNO_3$. It is best carried out, not with the oil itself, but with the unsaturated fatty acids obtained from it. The procedure is as follows:
The oil is saponified, neutralized with acetic acid, the lead soap precipitated by the addition of $Pb(C_2H_3O_2)_2$. The soap is washed with boiling water and then dried as completely as possible with filter paper. It is then treated with ether, the undissolved portion removed and the lead salts of the unsaturated acids decomposed by shaking the ethereal solution with HCl and water in a separating funnel. The ether is removed by distillation, the residue dissolved in 10 ccm 96 % alcohol, shaken with 1 ccm of 5 % $AgNO_3$ solution (aqueous) and warmed to 60—70°. If cottonseed oil is present, the solution becomes cloudy and finally throws down a black precipitate.
17. BETTENDORF'S REAGENT FOR ARSENIC. Conc. solution of stannous chloride in fuming HCl . Colourless solutions give with this reagent a brownish colour or a brown precipitate of arsenic, according to the amount present. The test is very sensitive.

18. BISMUTH SOLUTION (ALKALINE). $\text{Bi}(\text{NO}_3)_3$ solution is precipitated with excess of KOH and a solution of tartaric acid is added drop by drop until the precipitate is dissolved. The solution is used for the detection of glucose in urine.

19. BROMINE WATER. Obtained by shaking Br with cold water. It contains 2—3 % Br .

20. CALCIUM CHLORIDE. $\text{CaCl}_2 \cdot 6 \text{H}_2\text{O}$. Solution 1 : 5..

21. CALCIUM HYPOCHLORITE. $\text{Ca}(\text{OCl})_2$. 1 part bleaching powder rubbed to a paste with 20 parts H_2O .

22. CARO'S REAGENT FOR ALKALOIDS. Obtained by dissolving ammonium or potassium persulphate in conc. H_2SO_4 . The addition of the salt must be made slowly and the vessel must be cooled with ice. The paste when all the salt is added becomes solid. Its use depends upon its vigorous oxidizing action.

23. CITRIC ACID. $\text{C}_3\text{H}_4(\text{OH})(\text{COOH})_3$. 20 g of the acid in 1 litre H_2O .

24. COBALT NITRATE. $\text{Co}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$. Solution 1 : 10.

25. COPPER CHLORIDE. $\text{CuCl}_2 \cdot 2 \text{H}_2\text{O}$. Solution 1 : 10.

26. COPPER SULPHATE. $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$. Solution 1 : 10.

27. CUPROUS CHLORIDE. Cu_2Cl_2 . CuCl_2 solution is precipitated with SnCl_2 , the white precipitate washed successively with cold water, alcohol and ether, dried in a current of CO_2 at 90° and kept away from light and air. Used in gas analysis for the estimation of CO .

28. DENIGES' TEST FOR CITRIC ACID. 5 g mercuric oxide are dissolved in 20 ccm conc. H_2SO_4 and 80 ccm H_2O . 5 ccm of the 1—2 % solution containing citric acid are heated to boiling with 1 ccm of the reagent, and 2 % KMnO_4 solution added drop by drop. The solution is decolourized and a white finely crystalline precipitate is formed even if the solution only contains 1 part citric acid in 10000 parts of H_2O .

29. ERDMANN'S REAGENT FOR ALKALOIDS. 10 drops HNO_3 (S. G. 1.153) are diluted with 20 ccm distilled H_2O and 20 drops of this solution are added to 40 ccm pure conc. H_2SO_4 . To 1—2 mg of the alkaloid contained in a white porcelain dish, 1 ccm of the reagent is added. The reaction is complete in from 15—30 minutes. Temperature 18—22°. See "ALKALOIDS".

30. FEHLING'S SOLUTION, see "VOLUMETRIC ANALYSIS".

31. FERRIC CHLORIDE. Fe_2Cl_6 . Solution 1 : 20.

32. FISCHER'S REAGENT FOR SUGARS. 2 parts phenylhydrazine hydrochloride and 3 parts sodium acetate in 20 parts of water.

33. FROEHDE'S REAGENT. A solution of 0.5 g sodium molybdate in 100 ccm conc. H_2SO_4 gives characteristic colours with many alkaloids.

34. GOLD CHLORIDE. $\text{AuCl}_3 \cdot 2 \text{H}_2\text{O}$. Solution 1 : 20 used as a test for alkaloids. Solution 1 : 30 as a test for stannous chloride.

35. GRIESS' REAGENT. Used for the detection and colorimetric estimation of nitrous acid. 0.100 g pure white α -naphthylamine is dissolved by boiling for 15 minutes in 100 ccm H_2O , 5 ccm glacial acetic acid and 1 g sulphanic acid in 100 ccm water are added, and the mixture kept in a well-stoppered bottle. A very faint rose-red colouring of the reagent is not destroyed by the addition of 1 ccm to 50—100 ccm of the liquid to be tested; stronger colouration is destroyed by zinc dust. 1 ccm of the reagent shows the presence of $\frac{1}{10000}$ mg nitrous acid in 100 ccm water. A rose-tint appears after 10 minutes.

36. GRIGNARD'S REACTION. With metallic magnesium alkyl halides yield solid derivatives having the general formula RMg Hal. , where $\text{R} = \text{alkyl}$. $\text{Hal.} = \text{halogen atom}$. The organo-magnesium compounds so obtained are exceedingly reactive and have been of great service in the preparation of many organic compounds, and in the simplification of existing processes. See Chem. Zeitschr. III, 35, and IV, 315.

37. HALPHEN'S TEST FOR COTTONSEED OIL. Equal volumes of oil, amyl alcohol and carbon bisulphide saturated with S are heated for 10—15 minutes

in a boiling brine bath. When cottonseed oil is present a characteristic orange-red to red colour appears either at once or after standing for some time. This reaction does not occur if the oil has been previously heated to 250°.

38. HAEMATOKYLIN SOLUTION. 15 g logwood in chips are boiled for 48 hours with 100 g absolute alcohol. The filtered solution which must be kept in well stoppered bottles is used for the detection of Cu and Fe in drinkable water.

39. HELWIG'S BLOOD TEST. A solution of 1 part KI in 4 parts water dissolves dry bloodstains without altering the blood pigments.

40. HUBER'S TEST FOR FREE MINERAL ACIDS. A mixture of the aqueous solutions of ammonium molybdate and potassium ferrocyanide. In the presence of free acids the reagent is coloured reddish-yellow to dark brown.

41. HYDROCHLORIC ACID. HCl. Conc. acid S. G. 1.20 (39 parts HCl), S. G. 1.12 (24 parts HCl). Usually used at a dilution of equal parts of acid (S. G. 1.12) and water.

42. IODINE-POTASSIUM IODIDE-SOLUTION. 5 g iodine are triturated with 5 g KI and 100 ccm water and diluted to 1 litre.

43. IODINE-ZINC-STARCH-SOLUTION. 5 g powdered starch and 20 g $ZnCl_2$ are boiled with 100 ccm water (that lost by evaporation being replaced) until a clear solution is obtained. 2 g ZnI_2 are added and the whole diluted to 1 litre. The solution must be kept in the dark in well-stoppered bottles.

44. KNAPP'S SOLUTION FOR THE ESTIMATION OF GLUCOSE. 10.8 g HgCl are treated with KCN solution until the addition of NaOH causes no precipitate. 100 ccm NaOH solution (S. G. 1.145) are added and the whole diluted to 1 litre.

45. LEAD ACETATE. $Pb(C_2H_3O_2)_2 \cdot 3 H_2O$. Solution 1 : 10.

46. LUGOL'S SOLUTION, see "Iodine-potassium iodide-solution".

47. MAGNESIA MIXTURE. 1 part crystallized $MgSO_4$ and 1 part NH_4Cl dissolved in 8 parts water with the addition of 4 parts NH_3 (S. G. 0.96). After standing for some days the mixture is filtered.

48. MAGNESIUM CHLORIDE. $MgCl_2 \cdot 6 H_2O$. Solution 1 : 10.

49. MAGNESIUM SULPHATE. $MgSO_4 \cdot 7 H_2O$. Solution 1 : 10.

50. MANDELIN'S TEST FOR ALKALOIDS. A solution of 1 g of ammonium vanadate in 200 g sulphuric acid (monohydrate). The solution gives characteristic colours with alkaloids. E. g. strychnine gives a beautiful blue colour, changing to violet, cinnabar red and orange.

51. MARME'S REAGENT, see "POTASSIUM CADMIUM IODIDE".

52. MECKE'S TEST FOR ALKALOIDS. A solution of 1 part of selenious acid in 200 parts conc. H_2SO_4 gives characteristic colours with various alkaloids. Morphine:— blue turning blue-green to olive green.

Apomorphine:— dark violet.

Narcotine:— greenish-blue turning cherry-red.

Codeine:— blue, turning emerald-green, &c.

53. MERCURIC CHLORIDE. $HgCl_2$. Solution 1 : 16.

54. MERCURIC POTASSIUM IODIDE. $HgI_2 \cdot KI$. 13.35 g $HgCl_2$ and 49.8 g KI are dissolved separately in water, the solutions mixed and diluted to 1 litre.

55. MERCUROUS NITRATE. $Hg_2(NO_3)_2 \cdot 4 H_2O$. Solution 1 : 20. For the preparation of the salt see "MERCURY COMPOUNDS".

56. MEYER'S SOLUTION, see "MERCURIC POTASSIUM IODIDE".

57. MILLON'S REAGENT. Mercury is dissolved in an equal weight of HNO_3 (S. G. 1.41) at first in the cold and then with gentle warming. The solution is diluted with twice the volume of water, and after standing for some hours, decanted from the precipitate. It is used as a test for albumen.

58. MOHR'S SALT (Ferrous ammonium sulphate). This is used for standardizing $KMnO_4$ solution. It is preferred to $FeSO_4$ since it is less readily oxidized.

59. β -NAPHTHOL. $C_{10}H_7 \cdot OH$. The solution in NaOH is used as a test for $CHCl_3$ which is coloured blue by it.

60. NESSLER'S REAGENT. 35 g KI and 13 g $HgCl_2$ are heated to boiling with 800 ccm H_2O . The solution is treated drop by drop with a cold saturated solution of $HgCl_2$ until a permanent precipitate appears. 160 g KOH are then added, the whole diluted to 1 litre, a small quantity of $HgCl_2$ solution added, the solution allowed to settle and decanted from the precipitate. Must be kept in well-stoppered bottles.

61. NITRIC ACID. HNO_3 . Conc. acid S. G. 1.52 (100 % HNO_3). Diluted acid, S. G. 1.20 (32 % HNO_3). A more dilute acid (1 part acid, S. G. 1.20, and 3 parts water) is frequently used.

62. PALLADIUM CHLORIDE. $PdCl_2 \cdot 2 H_2O$. Solution 1 : 500. Used for the detection of CO.

63. PHENOL. $C_6H_5 \cdot OH$. Solution of 1 part phenol in 4 parts conc. H_2SO_4 after dilution with 2 parts H_2O serves as a test for HNO_3 ; a solution of phenol in KOH as a test for iodoform, a solution of phenol in mercurous nitrate solution as a test for nitrous acid.

64. m-PHENYLENE DIAMINE. $C_6H_4(NH_2)_2$. 5 g are dissolved in distilled water, dilute H_2SO_4 added until the reaction is distinctly acid, and the whole diluted to 1 litre. Used as a delicate test for nitrous acid.

65. PHLOROGLUCINE (sym. trioxybenzene). $C_6H_3(OH)_3$. Solution 1 : 200. Used for the detection of cellulose which is coloured violet-red by it.

66. PHOSPHOANTIMONIC ACID. Antimony chloride is dissolved in a solution of phosphoric acid. Reagent for alkaloids.

67. PHOSPHOMOLYBDIC ACID. The solution is obtained by the repeated evaporation of ammonium phosphomolybdate with aqua regia (to remove the NH_3), expelling the HCl by evaporation and dissolving the residue in water. Valuable for the detection of alkaloids.

68. PICRIC ACID. $C_6H_2(OH)(NO_3)_3$. Aqueous solution 1 : 100 test for alkaloids; aqueous solution, 1 : 250 test for hydrocyanic acid and glucose; cold, saturated, aqueous solutions of picric acid give characteristic precipitates with the aromatic hydrocarbons.

69. PLATINUM CHLORIDE. $PtCl_4 \cdot 10 H_2O$. Solution 1 : 10.

70. POTASSIUM BICHROMATE. $K_2Cr_2O_7$. Solution 1 : 10.

71. POTASSIUM CADMIUM IODIDE. 10 parts CdI_2 and 20 parts KI are dissolved in 80 parts H_2O . Used as a test for alkaloids with which it gives pale-yellow precipitates.

72. POTASSIUM CHROMATE. K_2CrO_4 . Solution 1 : 20.

73. POTASSIUM CYANIDE. KCN . Solution 1 : 5.

74. POTASSIUM FERRICYANIDE. $K_3Fe(CN)_6$. Solution 1 : 10.

75. POTASSIUM FERROCYANIDE. $K_4Fe(CN)_6$. Solution 1 : 10.

76. POTASSIUM HYDROXIDE. KOH. Solution 1 : 10. For organic analysis it is used 1 : 2.

77. POTASSIUM NITRITE. KNO_2 . Solution 1 : 3.

78. POTASSIUM SODIUM CARBONATE. Mixture of 13 parts K_2CO_3 and 10 parts anhydrous Na_2CO_3 . Used for the fusion of insoluble silicates and sulphates.

79. POTASSIUM THIOCARBONATE. K_2CS_3 . 12 g KOH are dissolved in 250 ccm water. Into half of this solution H_2S is passed until saturated. The other half is added, 10 ccm CS_2 allowed to run in, and the mixture gently warmed for two days in a loosely closed flask. The decanted dark-red liquid is used for the detection of nickel salts with which it gives a deep-brown colour.

80. SCHEIBLER'S REAGENT, see "SODIUM PHOSPHOTUNGSTATE".

81. SCHULZE'S REAGENT, see "PHOSPHOANTIMONIC ACID".

82. SILVER NITRATE. $AgNO_3$. Solution 1 : 20.

83. SODIUM ACETATE. $\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$. Solution 1 : 10.
84. SODIUM AMMONIUM PHOSPHATE. $\text{Na}(\text{NH}_4)\text{HPO}_4 \cdot 8\text{H}_2\text{O}$. 6 parts Na_2HPO_4 and 1 part NH_4Cl are dissolved in 2 parts of hot water, the solution allowed to crystallize, and the salt purified by repeated crystallization from water containing a little ammonia.
85. SODIUM CARBONATE. Na_2CO_3 . Solution (crystallized salt) 1 : 5, (anhydrous salt) 1 : 2.7.
86. SODIUM HYDROXIDE. NaOH . Solution 1 : 10.
87. SODIUM HYPOBROMITE. NaBrO . 100 g NaOH are dissolved in 250 g water, and to the cold solution 25 ccm Br are added. Used for the estimation of NH_3 and urea.
88. SODIUM HYPOCHLORITE. NaClO . NaOH solution is saturated in the cold with Cl and a few drops of NaOH solution are added until the smell of Cl has disappeared. It is used instead of bromine water as a vigorous oxidizing agent. Must be kept cool and in the dark.
89. SODIUM PHOSPHATE. $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$. Solution 1 : 10.
90. SODIUM PHOSPHOTUNGSTATE. 100 g sodium tungstate and 80 g Na_2HPO_4 are dissolved in 500 ccm H_2O acidified with HNO_3 . Test for alkaloids.
91. SODIUM SULPHIDE. Na_2S . Obtained by passing H_2S into NaOH solution. Sometimes used instead of ammonium sulphide.
92. SODIUM THIOSULPHATE. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$. Solution 1 : 10.
93. SODIUM TUNGSTATE. $\text{Na}_2\text{WO}_4 \cdot 2\text{H}_2\text{O}$. A saturated aqueous solution made strongly acid with glacial acetic acid. Used as a test for proteids. In dilute solution it gives bulky precipitates with albumen, caseine, glue, and blood serum.
94. SOLTSIEN'S TEST FOR SESAME OIL. 6 g of the oil under investigation are vigorously shaken with 2 ccm. BETTENDORF'S reagent (see No. 17) and warmed on the water bath. The tube is then allowed to stand in the water bath until the emulsion has separated. In presence of sesame oil the stannous chloride solution becomes rose-red or dark wine-red in colour. 1 % sesame oil can be recognized.
95. STANNOUS CHLORIDE. $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$. Pure granulated tin is dissolved in conc. HCl , the solution filtered through asbestos and kept over metallic tin. It is a strong reducing agent. If the solution be treated with NaOH until the precipitate first formed is redissolved a solution is obtained which is used for the estimation of glucose (method of KNAPP and SACHSSE).
96. STORCH'S TEST FOR BOILED AND UNBOILED MILK. A solution of 29 parts phenylenediamine in 100 ccm water. 5 ccm milk treated with 2 drops of the reagent and 1 drop of 0.2 % H_2O_2 solution turns indigo-blue in colour if it has not been previously boiled. The blue colour persists even after heating above 80° .
97. SULPHURIC ACID. H_2SO_4 . Conc. acid, S. G. 1.84 (100 % H_2SO_4). Diluted acid, S. G. 1.40 (50 % H_2SO_4). A diluted acid (1 part acid, S. G. 1.84, and 4 parts water) is also used.
98. TANNIN. Solution 1 : 10. A test for titanic acid. A solution of 1 part gallotannic acid in 8 parts water and 1 part alcohol is used as a test for alkaloids.
99. URANIUM ACETATE, see "VOLUMETRIC ANALYSIS".
100. WENZEL'S TEST FOR STRYCHNINE. A solution of 1 part KMnO_4 in 200 parts H_2SO_4 gives a violet colour with strychnine. The reaction is very sensitive, but the alkaloid must be free from every trace of other alkaloids and organic substances. Tartaric and citric acids, tartrates, citrates and thiocyanates are coloured blue-violet by the reagent, but the reaction is not

so well marked, nor does the colour persist so long as with strychnine.

Reagents:

Dr. C. L. Marquart, Chem. Fabrik, Bausel a. Rhein (Germany).

Realgar, see "ARSENIC COLOURS".

Rectification. Distillation for the purpose of removing one constituent of a liquid mixture as completely and rapidly as possible with the least possible consumption of fuel. This form of purification is of importance in the manufacture of ALCOHOL, BENZENE, PHENOL, &c. Compare the articles under these headings and under "DISTILLATION", FRACTIONATION".

The apparatus for rectification is based on two clearly defined principles. If a mixture of alcohol and water is heated, the vapours contain a higher proportion of alcohol than the liquid mixture, and the product of distillation consequently contains more alcohol, and has a lower boiling point than the original mixture. If the product is again heated to boiling point, a second product containing a still higher proportion of alcohol is obtained, and so on. Besides this, the essential principle of rectification, the principle of dephlegmation, comes into play. This principle is as follows. If the vapours consisting of alcohol and water are cooled below boiling point, but so that the temperature is still above that of the boiling point of alcohol, a mixture of alcohol and water which would boil at this temperature is condensed, while the vapours containing more alcohol remain uncondensed. By the combination of these two principles the rectification apparatus gives a high percentage spirit, or an almost pure benzene (from the corresponding tar oil) in one operation. Large numbers of flat copper basins placed one over the other often serve as a rectification arrangement in which the vapours entering from below are forced by curved pipes to pass through the condensed liquid contained in them. The vapours heat the contents of one basin to boiling point, whereupon they condense in the one above, until they are again volatilized. In the top basin a strong alcoholic mixture finally collects, while the water gradually separated during the passage from basin to basin finally returns to the still.

PISTORIUS' basins are generally preferred for this purpose. They are shallow, round, and made of copper with a loose double bottom which forces the entering vapours to pass along the sides. The lower inner surfaces of the basins are cooled by air and the upper surfaces by a current of water. The liquid which falls, containing little alcohol, flows back into the still, while the alcoholic vapours stream out through the upper tube of the PISTORIUS' basin, and thence into the cooler or into the basin above it, as the case may be.

These few remarks must suffice but it should be noted that there are a great many different varieties of rectification apparatus. Of these, the more modern are arranged for continuous work; that is the liquid flows into the apparatus in a continuous stream and the product of distillation and also the residue also pass out without interruption.

The principle on which depends a new apparatus for the rectification of spirit, benzol, ether, &c., which is protected by Germ. Pat. 140824, is mentioned in the article on "BENZENE".

Rectifying apparatus of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Rectifying apparatus of earthenware:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Red Mordant, see "ALUMINIUM MORDANTS".

Red salts.

1. Crude sodium acetate, see "ACETATES".
2. Crude K_2CO_3 coloured red by Fe_2O_3 .

Redwood (Pernambuco wood). Under this name are included several woods indigenous to the East Indies and South America. Different varieties are known as Brazil wood, California wood, Nicaragua wood, Japan wood, &c. The wood is used in the form of shavings, powder or extracts. The active principle is braziline which dissolves in alkalies with a carmine-red colour, and gives insoluble metallic lakes. On oxidation braziline yields brazileine.

Red wood is used in dyeing cotton (tannin and aluminium mordants) and wool (chrome mordants) red and brown shades. On cotton, orange shades with tin mordants, violet-grey with iron mordants, and dark purple with a mixture of iron and aluminium mordants can be produced.

Refractive Indices. The specific refraction of a substance is $\frac{n-1}{d}$ where n is the refractive index and d the density.

The product $\frac{n-1}{d} \cdot P$

where P is the atomic or molecular weight is the refraction constant of the element or compound respectively.

When x parts by weight of a liquid of refractive index n , and density d_1 are mixed with $100-x$ parts of weight of a liquid of refractive index n_2 and density d_2 according to LANDOLT the following equation holds:

$$x \frac{n_1-1}{d_1} + (100-x) \frac{n_2-1}{d_2} = 100 \frac{n-1}{d}$$

$$x = \frac{100 \left(\frac{n-1}{d} - \frac{n_2-1}{d_2} \right)}{\frac{n_1-1}{d_1} - \frac{n_2-1}{d_2}}$$

1. REFRACTIVE INDICES OF CERTAIN GASES AND VAPOURS.

Substance	Nat. ¹⁾ of light	Re- fractive index	Substance	Nat. ¹⁾ of light	Re- fractive index
Acetylene	D	1.000610	Hydrochloric acid.....	white	1.000449
Air	D	1.000294	Hydrocyanic acid	white	1.000451
Ammonia	white	1.000381	Hydrogen	white	1.000143
Bromine	D	1.001132	Methane	white	1.000449
Carbon bisulphide.....	white	1.001554	Nitrogen	white	1.000319
Carbon dioxide	white	1.000449	Oxygen	white	1.000270
Carbon monoxide	white	1.000340	Sulphur dioxide.....	white	1.000665
Chlorine	white	1.000772	Sulphuretted hydrogen	white	1.000639
Hydrobromic acid	D	1.000573	Water	white	1.000261

¹⁾ The letters denote the FRAUNHOFER lines of the spectrum, e. g. D=yellow sodium light.

2. REFRACTIVE INDICES OF CERTAIN LIQUIDS COMPARED WITH AIR [IN YELLOW LIGHT (D LINE)].

Substance	Temperature	Refractive index	Substance	Temperature	Refractive index
Acetaldehyde	20°	1.33157	Chloroform	10°	1.44900
Acetone.....	20°	1.35915	Ethyl alcohol.....	20°	1.36138
Acetic acid.....	20°	1.37182	Ethyl ether.....	15°	1.35660
Amyl alcohol	20°	1.40783	Glycerine	20°	1.47293
Aniline	20°	1.58629	Naphthalene	98°	1.58232
Benzene	20°	1.50144	Nitrobenzene	20°	1.55291
Bitter almonds, oil of	20°	1.54638	Phenol.....	20°	1.55033
Chloral	20°	1.45572	Toluene	20°	1.49552

3. REFRACTIVE INDICES (μ) OF CERTAIN DILUTE AQUEOUS SOLUTIONS.

Dissolved substance	μ	Dissolved substance	μ
Ammonium chloride	0.370	Potassium nitrate	0.231
“ nitrate	0.235	“ sulphate	0.248
“ sulphate	0.325	Rubidium sulphate	0.164
Lithium carbonate	0.577	Sodium chloride	0.394
Potassium chlorate.....	0.155	“ carbonate	0.377
“ chloride	0.278	“ nitrate	0.258
“ iodate	0.106	“ phosphate	0.292
“ carbonate	0.297	“ sulphate	0.271

Refractometers. These are instruments for determining refractive indices by observing the angle of total reflection in a body known to be of higher refractive index with which the body under investigation is brought into contact on a plane surface.

These are of three types, PULFRICH's, ABBE's and the immersion refractometers.

In PULFRICH's refractometer a 90° prism of strongly refracting glass is used. The horizontal upper face is brought into contact with the body under investigation, and the boundary lines of the homogeneous light entering the body are observed through the second (vertical) face.

The angle at which the limiting ray leaves the prism is determined by means of a telescope and a graduated arc, and from this and the known refractive index of the prism, the refractive index is calculated from tables. Liquids are examined in a glass tube cemented to the prism while solids must have two surfaces ground at right angles to each other.

In the ABBE refractometer there is a so-called ABBE' double prism. This consists of two fluid glass prisms with an angle of refraction of about 61° between which the liquid to be examined is placed in a thin layer (0.05 mm). In order to cut out extraneous rays the surface of one prism in contact with the liquid is ground to a matte surface.

The use of ordinary white light is made possible by the use of a compensator. These refractometers are chiefly used for liquids of refractive indices between 1.3 and 1.7 and are very easy to use. The observation is easily made either in daylight or by artificial light, after one simple adjustment, and the actual refractive index read off directly on an arc. Further, only a few drops of liquid are necessary for the determination.

These instruments are well adapted for the examination of food and drugs and serve as a means of identifying different substances and ascertaining their purity.

In the immersion refractometer the use of the second ABBE prism is unnecessary since the one prism is dipped into the liquid. By the proper choice of vessel used and the careful adjustment of the instrument the method of total reflection may be used. This method is of course only applicable when comparatively large quantities of liquid are available (e. g. for the determination of the alcohol and extractives in wine, beer, &c., the amounts of salts in seawater, mineral waters, &c.).

The instrument is, however, fitted with a supplementary prism which makes it possible to examine one drop of liquid. The observation may be made as easily as the determination of temperatures by a thermometer or of S. G. by the hydrometer.

Moreover the absence of the second prism in the usual type makes the reading more accurate, since a more powerful telescope may be used.

Refractometers for analytical and technical laboratories:

Carl Zeiss, Jena (Germany) Prosp. Mess., 160.

Refractometers:

Hans Heele, Berlin O. 27.

Rennet. (CALVES' RENNET.) An enzyme contained in the mucous membrane of the stomach of young calves, which curdles milk (separation of caseine). Rennet is employed for making cheese from fresh milk. It is sometimes used in the form of a powder, sometimes as a liquid, and sometimes as an essence.

The stomach is cut up into pieces, and extracted with dilute HCl. Glue and glycerine are added, and the whole is evaporated *in vacuo* at a temperature of about 40°. The process for making the essence is carried out in a similar way, except that certain ingredients such as alcohol, boric acid, common salts, &c., are added as preservatives. The chemical process involved in the making of rennet has not yet been explained. The most favourable temperature is between 35 and 40°. Compare also "PEGNINE".

Resin. (Resin, Common Resin; *Resina Pini*; *Pix Burgundica*). Natural as well as artificial products are sold as resin. Resin is obtained from turpentine (q. v.) which is a solution of resin in turpentine oil. The latter is removed, being either allowed to evaporate spontaneously on the trunk (natural resin) or it is distilled off by warming the turpentine with water. Another method is to heat the turpentine alone so that the essential oil gradually escapes. Of the various kinds of resins, the French Gallipot (obtained by distillation of turpentine with water) and Burgundy pitch (obtained from the resin of *Picea vulgaris*) are best known.

According to the Amer. Pat. 783367 pine wood is dipped into hot or cold alcohol. A pure solution of turpentine is thus obtained, all impurities remaining in the wood. On heating the solution the alcohol is driven off and then the turpentine removed by distillation, the residue being practically pure resin.

According to the Germ. Pats. 142459 and 151109 decolourization of resin is secured by treatment with alkaline substances (actual boiling is avoided as it would cause saponification) in the presence of H₂O, steam or CO₂ which forms an indifferent atmosphere.

Resins. Soft or hard vegetable secretions, which are insoluble in H₂O but more or less soluble in essential oils, chloroform, ether, alcohol, &c. Resins are further classed as resins proper, balsams, gum resins, and fossil resins. The balsams, gums, and fossil resins are treated of in separate articles. The resins

sometimes occur already formed in the plant, but as a rule they develop from the balsams after these have exuded. The balsams are solutions of resin in essential oils and the resins remain behind when the oils evaporate. The resins which are of technical importance are treated of in special articles, and will be found under BENZOIN, DAMMAR, DRAGON'S BLOOD, ELEMI, COMMON RESIN, GUAIACUM RESIN, COPAL, MASTIC, and SHELLAC.

By the term RESIN the common resin of pines is generally understood (q. v.). The method of preparation of resin discovered a few years ago from the cumarone and indene compounds present in coal tar, is an extremely interesting one. These substances have a strong tendency to polymerize to resinous bodies. In this form, as cumarone resin and indene resin, they are already considerably used in the manufacture of lacquer varnish. The Engl. Pat. 12880 (1902) protects the synthetic preparation of resin-like substances which can be substituted for shellac in the manufacture of lacquer varnishes. Organic oxy-acids, such as tartaric, &c., are mixed with a formaldehyde solution in a lead-lined double vessel, phenol is then added and the whole is heated until it boils vigorously. The resinous mass which then rises to the surface is washed with hot H_2O , purified by boiling with a little NH_3 and poured into cold water to solidify.

Dr. CARL GOLDSCHMIDT also refers to the artificial preparation of a resin by means of formaldehyde by a method which is of practical and industrial value. He recommends the manufacture of sealing wax from the resin obtained from formaldehyde, methyldiphenylamine and HCl, by heating and oxidizing these substances for 2 hours. A substitute for copal is made by allowing monomethylaniline to remain in contact with excess of formaldehyde and HCl. The resin is then precipitated with caustic soda, filtered and cooled.

Resin colours. Obtained by mixing or melting resins with dyestuffs. Some are prepared directly from the resins.

According to French Pat. 356988 hard, very stable colours suitable for all purposes are obtained by mixing resin with dyestuffs with no addition of solvent or diluting medium. The colours are mixed for use with essential oils, alcohol, &c., and dry very quickly.

Resin oils. The products of the dry distillation of colophony. The colophony is heated in large, low, iron stills, with heads, cooling apparatus and receiver. The heating is sometimes carried out over an open fire but it is more satisfactory to use superheated steam. During the process of distillation, acid, aqueous liquids first pass over which are worked up into acetic acid. These are followed by a light volatile yellow oil which has a perfume similar to thyme, and is termed RESIN SPIRIT, resin essence or pinoline. At a higher temperature a thick, white fluid with a blue reflex distils—the so-called thick oil of resin. Finally a thin, yellow fluid which also has a blue tinge is obtained (thin oil of resin). Both the thick and the thin oils of resin come into the market as crude oil of resin. They are mostly used as lubricants. The residue in the still is the so-called smith's pitch, and forms one of the ingredients of cobler's wax.

As a rule the oils of resin are not used in a crude state, but undergo a process of refining. Pinoline is purified by being first distilled and then rectified with caustic lime and water. The real oils of resin are purified by stirring with caustic soda or H_2SO_4 and then washing with H_2O . Those which are treated with more concentrated caustic soda are distilled, and finally clarified by standing over gypsum.

The process, lately introduced, of distilling colophony *in vacuo* has proved very satisfactory. The products obtained are usually known as essence of resin, "pale resin oil", blue, or green oil of resin.

For obtaining light stable oils of resin which may be readily emulsified, the crude resin oil is boiled with excess of caustic soda lye, by direct steam. This process is protected by Germ. Pat. 148168. The alkaline resin oil mixture thus obtained is treated with compressed air or ozone at a temperature of 95° to 110° till a clear solution is obtained. The product is soluble in water or readily forms an emulsion. It is employed as a preservative for wood and for other purposes.

Resorbine. A fatty emulsion used as a basis for salves, &c., made of almond oil, wax and water and thickened by the addition of a little gelatine and soap.

Resoreine. m-dioxybenzene. $C_6H_4(OH)_2$. ($OH : OH = 1 : 3$). The substance is obtained from benzene disulphonic acid by fusion with KOH. Pure benzene, free from toluene, is sulphonated by heating a mixture of 5 parts of H_2SO_4 of 64° Bé with 1 part of benzene to a moderate temperature with continuous stirring (indirect steam). The benzene monosulphonic acid thus obtained is heated for 8 hours with the excess of acid and an addition of 25% of sodium sulphate, the temperature being kept at about 230°. The result is that benzene disulphonic acid (chiefly the m-compound) is formed. The product is treated with H_2O and neutralized with lime water to form the calcium salts. By adding soda and heating to boiling point the sodium benzene disulphonate is obtained. This is then filtered and evaporated to a solid mass. To change it into resorcine 230 kg of NaOH are fused with a few liters of water, in an iron vessel with a stirring arrangement. 125 kg of sodium benzene disulphonate are added as quickly as possible taking care that the temperature does not exceed 270°.

When the whole has become brown and oily, the melt is allowed to solidify. After cooling the mass is broken up and acidified with HCl, whereupon the resorcine separates from the sodium resorcine formed. The resorcine is then shaken several times in a special apparatus with fusel oil, the amyl alcohol solution is drawn off and distilled with steam, and an aqueous solution of resorcine remains in the still. This residue is then carefully dried by evaporating and finally distilled *in vacuo*.

When pure, it forms colourless, sweet crystals slightly rasping to the taste which dissolve readily in H_2O , alcohol and ether, but with difficulty in boiling C_6H_6 . These crystals have a boiling point of 271° and melt at 110°. At 271° the crystals partially decompose. The aqueous solution has a sweet taste; $FeCl_3$ colours it a deep violet.

If resorcine is heated with phthalic anhydride to about 200°, fluorescein is formed (q. v.). The fused product dissolves in weak alkaline solutions or in ammonia giving a solution with a strong green fluorescence. Resorcine is principally employed for the manufacture of tar colours, but is also used in medical practice.

TEST. Commercial resorcine is as a rule fairly pure. In appearance, which is that of a crystalline substance, it should be very slightly coloured. It should not turn brown on exposure. It should further show the proper melting point and dissolve in water to a clear slightly-coloured liquid having only a suspicion of the smell of phenol. The water present is determined by drying a powdered sample over H_2SO_4 .

Retort graphite. A solid substance containing much carbon. It separates in the form of a hard dense layer on the walls of the retorts used in the manufacture of coal gas. It is used for the preparation of graphite crucibles, carbon electrodes, &c.

Retorts.

Retorts of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Blücher.

Reuniol. A terpene alcohol with a strong rose-like odour obtained from geranium oil. It is apparently a mixture of citronellol (q. v.) and geraniol (q. v.)

Rexotan. Methylene-tannin urea. It is obtained by the condensation of urea and tannin by means of formaldehyde.

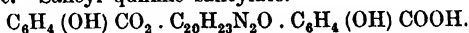
A yellow-brown, amorphous, odourless, tasteless, powder. Used medicinally as an intestinal antiseptic and astringent.

Rheumasan. A superfatted soap-cream to which 10 % of salicylic acid are added.

The substance is recommended for rubbing in cases of rheumatism. It is readily absorbed and quite stable.

Rheumasol. A dark brown liquid, consisting of 10 parts of salicylic acid, 10 parts „Petrosulphol” (apparently identical with ichthyol) and 80 parts salicylvasol. It is used as a paint and external dressing in cases of skin diseases, inflammation, and rheumatic troubles.

Rheumatine. Salicyl quinine salicylate.



White crystalline needles, M. P. 179°, sparingly soluble in water. Recommended as a substitute for salicylic acid over which it has several advantages. Dose:—1 g three times daily, with an interval of a day after 3—4 days.

Rhexite, see “DYNAMITE” and “SAFETY EXPLOSIVES”.

Rhodamines see “PYRONINE DYESTUFFS”.

Rhodinol. A terpene alcohol prepared from the oils of rose, geranium, and citronella. It is really geraniol (q. v.) free from impurities.

Rhodium. Rh. A. W. = 103.0. Rhodium is one of the platinum metals. S. G. 12.11. It has a silver-white lustre, is less readily fusible than platinum and when pure is insoluble in aqua regia. It has been used recently alloyed with platinum in the construction of pyrometers. It has been also used in the preparation of colours for painting porcelain. These colours all have a greater resistance after firing when rhodium is present.

Rhodium and compounds:

Johnson, Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Roasting. The process of heating ores to a temperature below the melting point but high enough to cause disintegration. They are thus brought into a condition suitable for the action of reagents. Generally some chemical process is combined with the roasting, e. g. a portion of the ore is oxidized by the action of the oxygen of the air.

The roasting is carried out in furnaces of different types. Reducing, chlorinating, and sulphonating processes are also often carried out in conjunction with the roasting.

Roborate. A food preparation consisting of pure vegetable proteid. It is obtained from grain as a tasteless powder as fine as dust. The greater part is soluble in water and easily digested. It contains 11—12 % water and 83 % proteid (95 % of the dry weight).

Roburite, see “SAFETY EXPLOSIVES”.

Rodinal, see “PHOTOGRAPHIC CHEMICALS”.

Roman cement see "CEMENT."

Rongalite, see "HYDROSULPHITES".

Rosamine = benzorhodamine. The rhodamines are discussed under "PYRONINE DYESTUFFS".

Rosaniline dyestuffs = amidotriphenylmethane dyestuffs.

Roseine, see "NICKEL ALLOYS".

Rose, oil of. Obtained by the distillation of rose petals with water; fractions are generally separated and these are usually rectified. In Turkey the oil is taken from the distillate after standing for 1—2 days, while by more modern methods the oil is separated from the aqueous distillate by using a Florence flask as receiver. The aqueous residue is sold as rose water, while a less strong rose water is obtained by mixing two drops of oil of rose with 1 litre of water. The fresher the leaves the better is the oil; it is now also made in Germany of a very excellent quality.

Pale yellowish liquid S. G. (at 20° C) 0.855—0.865; B. P. 229°. The odour is not due to stearoptene — a paraffin $C_{16}H_{34}$, M. P. 36.50 — which causes the oil to solidify at 12—20° C but the claeoptene which remains liquid.

ARTIFICIAL OIL OF ROSE is prepared by different methods. According to Germ. Pat. 126736 certain aliphatic aldehydes of high molecular weight are added to a mixture of the main constituents of oil of rose (geraniol, citronellol, phenylethyl alcohol, citral and linalool). The following mixture will serve as an illustration:— Parts by weight. Geraniol 80, citronellol 10, phenylethyl alcohol 1, linalool 2, citral 0.25, octylic aldehyde 0.5. Instead of octylic aldehyde, heptylic and decylic aldehydes may be successfully substituted.

Rosemary, oil of. An essential oil obtained by distillation with steam from the leaves and flowers of the rosemary (*Rosmarinus officinalis*). Colourless or pale yellow; S. G. (at 15°) 0.900 to 0.915. It has a penetrating aromatic odour and becomes resinous in the air.

The best kinds in order of value are the Italian, French, and Dalmatian. The Spanish and German oils are less valuable. It is used in perfumery and medicine, for the destruction of insects, for denaturing olive oil, and for varnishes.

Rose's metal, see "BISMUTH ALLOYS".

Rosindulines, see "SAFFRANINES".

Rosolic acid. (Aurine). For constitution and preparation, see "OXYTRI-PHENYLMETHANE DYESTUFFS". It is used as an indicator. See "ALKALIMETRY" and "INDICATORS".

Rubidium and Rubidium compounds.

Rubidium. Rb. A. W. = 85.4. A soft silver-white metal, resembling potassium. S. G. 1.52; M. P. 38.5°. It oxidizes readily in the air, and when thrown into water burns with a violet-coloured flame. It occurs with potassium in the Stassfurt salts (see "ABRAUM SALTS"). The metal is prepared by heating the hydroxide RbOH with Mg or Al.

Rubidium alum $Rb_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ is the most important salt, on account of its being used for the separation of K from Rb. Its solubility is only one-sixth of that of ordinary alum. From this compound other rubidium salts can be prepared.

Rubies, artificial, see "CORUNDUM, ARTIFICIAL".

Rust preventives. The rusting of iron is caused by oxidation induced by atmospheric oxygen and the simultaneous action of H_2O . For this reason iron never rusts in dry air nor in water from which air is excluded. It is also supposed that pure air, consisting of N and O with H_2O does not rust iron, but that the CO_2 of the atmosphere is a necessary factor. In this way ferrous carbonate $Fe(HCO_3)_2$ is formed and this passes into ferric hydroxide. The rust forms a porous and hygroscopic coating. It does not protect the inner parts of the metal from the further action of the air. On the contrary the metal goes on rusting until the whole is converted into hydroxide. It should be noted that hard cast iron, with a large proportion of carbon contents, rusts far less readily than wrought iron and steel.

If iron is placed under H_2O mixed with CaO , Na_2CO_3 , $NaOH$ or any other substance which can combine with CO_2 it will remain free from rust as long as these compounds continue to absorb CO_2 . Another method for protecting the iron is to „galvanize” it, that is to coat it with zinc. Again, iron can be enamelled with different metals such as Cu, Pb, Ni, bronze, Ag, Sn and Zn. Tin only protects from rust so long as it completely covers the iron — indeed it induces rusting as soon as the coating is defective at any point.

The above-named method of galvanizing is much more satisfactory, for it protects the iron, especially under water, all the better for being defective, that is when the zinc coating shows bare places. In this case the combination of Fe and Zn, in presence of H_2O acts as a galvanic element, the Zn being the electropositive metal. O is liberated on the Zn while H is set free on the Fe, thus rendering impossible any rusting of the iron. Compare also ZINC PLATING. Other methods of preventing rust are those of painting and coating the iron with oil colours, mixtures of mineral colours with fats and resins, alcoholic solutions of resin with colours, of the same mixtures of resin and colour in turpentine oil. A well known plan is also to “brown” the iron to prevent rust. This method is much used for fire arms, gun barrels, &c. which are thus covered with a thin coating of iron oxide which does not easily wear off. Compare “METAL COLOURING”. An excellent preventive of rust for painting iron can be made by melting 50 g of wax with 5—20 g of lanoline.

Germ. Pat. 156441 protects the manufacture of a rust preventive for gun barrels in which nitropowder is used. This substance consists of an ointment made of glycerine, vasogene, and ammonium carbonate. “Compare VASOGENE”.

Ruthenium. Ru. A. W. = 101.7. One of the platinum metals (q. v.) occurring in platinum ore and in osmiridium. S. G. 12.26, very brittle, when massive it is infusible even in the oxyhydrogen flame. It is more readily fusible than Os. Pure Ru dissolves with difficulty in aqua regia giving Ru_2Cl_6 .

Ruthenium and compounds:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

S

Saccharimeter, see “POLARIZATION”.

Saccharine, see “SWEETENING SUBSTANCES”.

Saccharose, see “SUGARS”.

Safety explosives. The knowledge that a great number of fire damp and mine gas explosions have been caused by blasting materials resulted in a

commission to inquire accurately into the nature of dynamite and kindred substances in relation to their danger or otherwise in presence of choke damp. In consequence of the report given by this commission, the use of black powder and dynamite in mines where black damp, &c., is present has been forbidden by law. The makers of explosives have since then brought forward new substances as safety blasting powder and safety explosives which may be considered as safe to employ even where damp is known to be present. The principle constituent of most of these patent mixtures, — apart from carbonite — is ammonium nitrate. As this material cannot of itself be made to explode it is mixed with other substances, such as collodion-wool, resin, potassium bicarbonate, potassium nitrate, naphthalene, nitro-naphthalene, sawdust, and most frequently of all, nitroglycerine.

The safety of such mixtures naturally depends on the proportion of the ammonium nitrate present. A very powerful explosive, for instance, called donarite consists of 80% ammonium nitrate, 12% trinitrotoluene, 4% flour, 3.8% nitroglycerine and 0.2% collodion wool. This mixture can of necessity make but a weak claim to be called a safety explosive.

Other safety explosives contain, instead of ammonium nitrate, other kinds of nitrates as for instance potassium nitrate, sodium nitrate or barium nitrate. Germ. Pat. 123641 protects the preparation of a material which is rendered less dangerous by the substitution of sodium or barium nitrate for a portion of the ammonium nitrate. The example given is 91% ammonium nitrate, 5% resin, and 4% sodium or barium nitrate. Germ. Pat. 112067 makes use for the same purpose of a small proportion of potassium nitrate and ammonium nitrate, and resin. According to Engl. Pat. 3334 (1902) uncombined ammonia is set free on exploding. This NH_3 acts as a flame extinguishing agent. Turpentine oil can also be added to ammonium nitrate explosives to cause the setting-free of ammonia.

According to Engl. Pat. 11325 and 22645 (1902), explosives containing hygroscopic salts can be mixed with gelatinous solutions of glue, glue and glycerine, dextrine and other kindred substances.

The aluminium explosives which are comparatively safe are very powerful, for which reason they are preferred. As the effect of these explosives is very similar in principle to GOLDSCHMIDT's thermite process, they have been given the name of thermite explosives. Compare "THERMITE". Ammonal and Brockite given in the list below belong to this class. Eng. Pat. 25540 (1902) asserts that the effect of these aluminium explosives is much heightened, if instead of aluminium powder, an aluminium wool is made use of. For instance 80 parts of picric acid are mixed with 20 parts of aluminium wool, or 85 parts of westphalite with 15 parts of aluminium wool. All these kinds of explosives, one would suppose, would lose some of their power on keeping through the oxidation of the aluminium.

A few examples of the most important of the so-called safety explosives are given below.

AMMONAL. A mixture of ammonium nitrate and aluminium. 95% Ammonium nitrate and 5% Aluminium have been suggested as the best proportions to use. Sometimes charcoal or similar substances are added.

AMMON CARBONITE. 9% Ammonium nitrate, 6% flour, 3.8% nitro-glycerine and 0.2% collodion wool. The hygroscopic nature of the ammonium nitrate is according to Germ. Pat. 129481 neutralized by covering the finished product with flour made into a paste.

AMMON-FOERDITE I. 85% ammonium nitrate, 4% flour, 3.8% nitroglycerine 0.2% collodion wool, 2% glycerine, 1% diphenylamine, 4% potassium chloride.

AMMONITE. 88% ammonium nitrate and 12% dinitronaphthalene. This is an English invention.

BELLITE I. 83.5 % ammonium nitrate and 16.5 % dinitrobenzene.

BELLITE III. 93.5 % ammonium nitrate and 6.5 % dinitrobenzene. Bellite I and III are also English invention.

BOBBINITE. 62—65 parts of potassium nitrate, 17—19.5 parts of charcoal, 1.5—2.5 parts of sulphur, 13—17 parts of copper sulphate and ammonium sulphate. The mixture is pressed into cylindrical form and covered with paraffin.

BROCKITE. Engl. Pat. 2977 (1903). A mixture of barium chlorate and aluminium powder.

CARBON CARBONITE. 25 % nitroglycerine, 34 % potassium nitrate, 1 % barium nitrate, 38.5 % wheaten flour, 1 % ground tan, and 0.5 % soda. This is the oldest carbonite known and is considered to be one of the safest.

CARBONITE I. 25 % nitroglycerine, 30.5 % sodium nitrate, 39.5 % flour and 5 % potassium bichromate. The preparation of this explosive which is more powerful than the carbon carbonite mentioned below, is protected by Germ. Pat. 97852.

CARBONITE II. 30 % nitroglycerine, 24.5 % sodium nitrate, 40.5 % flour, and 5 % potassium bichromate.

This is a still more powerful blasting substance than carbonite I.

COLOGNE-ROTTWEILER SAFETY BLASTING POWDER. 93.0 % ammonium nitrate, 0.9 % barium nitrate, 1.2 % sulphur, and 4.9 % vegetable oil.

CORONITE. 38—40 parts of nitroglycerine, 1—1.5 parts of soluble gun-cotton, 26 to 28 parts of ammonium nitrate, 3—5 parts of potassium nitrate, 11—14 parts of aluminium stearate, 8—11 parts of rye flour, 2—4 parts of sawdust, and 2—4 parts of liquid paraffin.

DAHMENTE A. 91.3 % ammonium nitrate, 64.75 % naphthalene and 2,225 % potassium dichromate.

FOERDITE. 25.5 % nitroglycerine, 1.5 % collodion wool, 5 % nitrotoluene, 4 % dextrine, 3 % glycerine, 37 % ammonium nitrate, 24 % potassium chloride.

GELATINE CARBONITE. 25.3 % nitroglycerine, 0.7 % collodion wool, 6.9 % gelatine (1 glycerine: 3.5 % glue), 25.6 % sodium chloride and 41.5 % ammonium nitrate.

NEGRO OR NIGGER POWDER. 86—91 parts of ammonium nitrate, 9 to 11 parts. of trinitrotoluene and 1—3 parts of graphite.

PETROCLASTITE. A mixture of saltpetre, sulphur, coal-tar pitch and potassium bichromate. This only explodes in a closed space or bore; in the open air it burns quietly. It is ignited in the same way as black powder with a fuse without a percussion cap. As the law does not class it among explosives it can be sent by rail as common goods.

ROBURITE I. 87.5 % ammonium nitrate, 7.0 % dinitro-benzene, 0.5 % potassium permanganate, and 5.0 % ammonium sulphate.

ROBURITE III. 87 % ammonium nitrate, 11 % dinitrobenzene and 2 % chlornaphthalene.

SAFETY DYNAMITE. 24 % nitroglycerine, 1 % gun-cotton, and 75 % nitrate of ammonium.

VIGORITE. 76 % ammonium nitrate, 10 % potassium nitrate, 2 % resin, 2 % potassium chlorate and 10 % nitrated hydrocarbons.

WESTPHALITE I. 95 % ammonium nitrate and 5 % resin.

WESTPHALITE II. 91 % ammonium nitrate, 3 % potassium and 5 % resin.

WESTPHALITE, IMPROVED. 92 % ammonium nitrate, 3 % potassium nitrate, 5 % resin.

WITTENBERG DYNAMITE. 25 % nitroglycerine, 34 % potassium nitrate, 1 % barium nitrate, 38.5 % rye flour, 1 % wood dust, 0.5 % sodium bicarbonate.

Safety explosives:

Westfälisch-Anhaltische Sprengstoff-A.-G., Berlin W. 9.
Sprengstoff-A.-G. Carbonit, Hamburg.

Blasting gelatine:

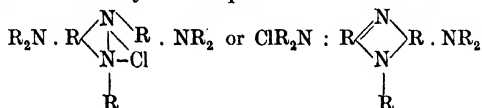
Werner Pfeleiderer & Perkins Ltd., Peterborough.

Safflower. The dried dark reddish-yellow flowerheads of the safflower (*Carthamus tinctorius*) contain a soluble yellow and an insoluble red dyestuff, of which only the latter, carthamine, is used. It is sold as a suspension in water (safflower carmine) and partly in the form of a dried paste. It was formerly used for red shades on cotton, wool and silk but is now replaced by coal-tar dyes.

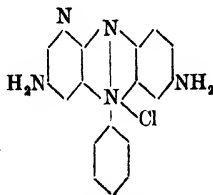
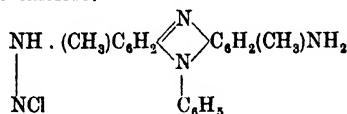
Saffranines. Saffranine dyes are coal-tar dyes of the azine group (q. v.) containing, like these, the chromophore group



There are 4 N-atoms present in the true saffranines and at least 3 hydrocarbon nuclei. These dyes correspond to the formulae:



and are formed by the condensation of an indamine (q. v.) with another primary monamine. An indamine may be heated with a primary amine, or a p-diamine be oxidized with 2 mol. of the base (one of which is primary), or by oxidizing a p-diamidodiphenylamine (or an analogous compound) with a primary base. Finally saffranines are formed when amines act on amidoazo-substances; the latter split into a p-diamine and a monamine. The simplest dyestuff of this type, obtained by the oxidation of 1 mol. para-phenylenediamine with 2 mol. aniline by $K_2Cr_2O_7$ or MnO_2 and acetic acid is phenosafranine. The homologue of which is the true saffranine. The latter, toluene o saffranine chloride:—



Phenosafranine

is now only prepared by the oxidation of equal molecules p-toluylene diamine and o-toluidine and condensation of the indamine thus obtained with toluidine (or aniline). This method, exclusively used for the commercial preparation of saffranines, is based on the oxidation of 1 mol. p-diamine with 2 mol. monamine.

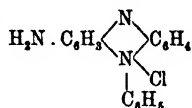
The respective mixture of bases is obtained by the reduction of azo-substances. As a rule a mixture of amidoazotoluene and o-toluidine is prepared

by the action of $\text{NaNO}_2 + \text{HCl}$ on o-toluidine, from this a mixture of 1 mol. p-toluylenediamine + 2 mol. o-toluidine is obtained by reduction with zinc dust or Fe and HCl. The mixture, in dilute solution neutralized with CaCO_3 , is oxidized by boiling with $\text{K}_2\text{Cr}_2\text{O}_7$ or MnO_2 , the indamine thus formed being condensed to saffranine with the excess of monamine. Toluensafranine is chiefly used in cotton dyeing. By adding yellow dyes a scarlet, much like Turkey red though less fast, is obtained.

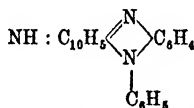
It should be noticed that the first aniline dyestuff commercially prepared was mauveine, a phenylated toluensafranine.

Frequently safranines are subdivided into benzosafranines and naphthosafranines. Among the latter is magdala red (naphthalene red) obtained by heating α -amidoazonaphthalene with α -naphthylamine.

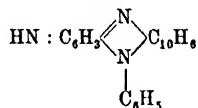
The so-called aposafranines differ from the safranines in that they contain fewer amido-groups and are therefore less basic in character. The simplest aposafranine



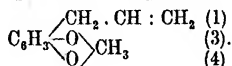
is obtained by boiling the primary di-azo compound of phenosafranine with alcohol. Some other aposafranines, formerly included among the indulines (q. v.) are the rosindulines and isorosindulines which must be regarded as analogous to aposafranines. A benzene residue of these two latter groups is substituted by a naphthalene group. The formula of the simplest rosinduline is:—



and that of the simplest isorosinduline:—



Saffrol. An important compound used in perfumery. Its constitution is



It is found in oil of camphor, oil of sassafras, &c. From the latter, saffrol (90 %) is obtained by cold pressing or by distillation with water. A colourless or pale yellow liquid B. P. 233° which solidifies on cooling to a crystalline mass melting at $+11^\circ$. It is used for the preparation of isosaffrol and piperonal (see these).

Saffron. The dried flower buds of the saffron (*Crocus sativus*) which contain a yellow dyestuff, CROCEINE. Saffron is now only used for colouring food, &c. and as a spice.

Salodine. The calcium salt of monoiodobehenic acid obtained from the erucic acid of rape oil by treatment with hydriodic acid.

The formula is $(C_{22}H_{42}O_2I)_2Ca$. It is a colourless, tasteless, odourless powder, insoluble in water; it contains 26 %. It is used medicinally as an iodine preparation in the treatment of certain diseases. Daily dose 1–3 g.

Salacetol = acetolsalicylic ester. $C_6H_4(OH)CO_2CH_2COCH_3$. Obtained by heating monochloracetone with sodium salicylate.

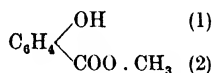
Small colourless crystals with a slightly bitter taste. M. P. 71° , sparingly soluble in H_2O , more readily in alcohol and oils. It is prescribed instead of sodium salicylate for articular rheumatism, in doses of 2–4 g per diem.

Salenal. An ointment containing $33\frac{1}{3}$ % salene. Used for rheumatism.

Salene. A mixture in equimolecular proportions of methyl- and ethylglycolic acid esters of salicylic acid. An oily liquid, said to be used alone or mixed with alcohol as an ointment in cases of rheumatic complaints.

Salibromine = methyldibromsalicylate. $C_6H_2Br_2(OH)CO_2CH_3$. Powder, insoluble in H_2O , soluble in alkalies. Prescribed as an antirheumatic and antipyretic.

Salicylate, methyl.



It occurs to the extent of 90 % in oil of wintergreen, *Oleum gaultheriae* (q. v.). It is, however, generally prepared synthetically by the distillation of two parts of salicylic acid, 2 parts methyl alcohol and 1 part concentrated H_2SO_4 . It is called artificial oil of wintergreen and is a strong aromatic perfume, used in perfuming soaps, in the preparation of fruit essences, &c. S. G. (at $16^\circ C$) 1.1819; B. P. 224° . Ethyl salicylate prepared in an analogous manner has a similar odour and is used for the same purposes.

Salicylic acid. $C_6H_4(OH) \cdot CO_2H$. This acid occurs in a free state or in the form of its methylester in various parts of different plants. For practical purposes, however, it is always prepared synthetically. The process is as follows. Phenol is neutralized with caustic soda and the sodium phenolate thus obtained after drying is exposed to the action of dry CO_2 at the ordinary temperature so long as absorption takes place. Phenyl sodium carbonate is formed according to the equation: $-C_6H_5 \cdot ONa + CO_2 = C_6H_5O \cdot CO_2Na$. After this has been heated for several hours in autoclaves to about 140° the phenyl sodium carbonate is decomposed into sodium salicylate which is a dry dusty substance. This is dissolved in H_2O , precipitated by a mineral acid and finally purified by recrystallization. In place of this patented method, more or less important modifications have lately been introduced, e. g. well dried sodium phenolate is placed in the autoclave and the necessary quantity of CO_2 is pumped in under the proper pressure. After the autoclaves are cool, they are kept closed and left for some hours to complete the reaction. The autoclave is then heated to 120 – 140° when the decomposition of the phenyl sodium carbonate into sodium salicylate takes place.

MARASSE's patented process is simpler. A mixture of phenol and potassium carbonate is heated in a closed vessel to 130 – 160° and CO_2 is allowed to act simultaneously. It is important that care should be taken that to 1 part phenol about 3 parts of potassium carbonate are used so as to avoid by the excess of K_2CO_3 any danger of the substance being melted. The changes correspond to the equation: $-2 C_6H_5 \cdot HO + K_2CO_3 + CO_2 = 2 C_6H_4(OH) \cdot CO_2K + H_2O$.

The purest salicylic acid is obtained from synthetic phenol. Compare "PHENOL". Germ. Pat. 133500 gives the following directions:— The melted mass obtained in the synthetic preparation of phenol, which consists of sodium phenolate and sodium sulphite is placed while hot on iron plates and allowed to cool. It is then converted, by a current of CO_2 , into sodium salicylate. From the sodium salts the salicylic acid is separated in the usual way. This method avoids the necessity of separating and purifying the phenol and thereby effects considerable economy of material and labour.

To obtain the anhydride of salicylic acid, salicylide $\text{C}_6\text{H}_4 \begin{smallmatrix} \diagup \text{CO} \diagdown \\ \diagdown \text{O} \diagup \end{smallmatrix}$, salicylic acid

is warmed with phosphorus oxychloride. The following method is protected by Germ. Pat. 134234. Acetylsalicylic acid is heated for 5–6 hours to 200 – 210° , the product of the reaction is extracted with H_2O , dissolved in acetone or a similar solvent and then precipitated with H_2O . The salicylide thus obtained is a white powder which dissolves in chloroform, glacial acetic acid and benzene. At 110° it begins to sinter and melts completely at 261° . Salicylide is used for pharmaceutical purposes and is said to serve in the preparation of other derivatives such as nitrosalicylide, &c.

Pure salicylic acid forms colourless crystals, the technical product however occurs as yellowish-white crystals. The taste is acid and at the same time rather sweet. M. P. 156° . It sublimes at 200° and distils in superheated steam at 170° . At 15° it dissolves in 444 times its bulk of water. At 100° in 12.6 parts. It is also soluble in alcohol and ether. This acid serves as a preservative; it is also used as a medicine and for disinfecting purposes. It is also employed in dye works and for the manufacture of several artificial perfumes.

Salimenthol, menthol salicylate. A pale yellow pleasant-smelling liquid used externally and internally as an antiseptic and as an anodyne in cases of toothache, rheumatism, &c.

Salipyrine. Antipyrine and salicylic acid in proper proportions are warmed on the water bath; the mixture melts to an oily liquid which solidifies on cooling. The salt is purified by recrystallization from alcohol.

Colourless, odourless crystalline powder M. P. 92° , sparingly soluble in cold, more readily in hot H_2O , moderately soluble in alcohol and in ether, easily soluble in chloroform. It is prescribed as an antipyretic and antineuralgic.

Salite = Bornyl salicylate. $\text{C}_{10}\text{H}_{17}\text{O} \cdot \text{CO} \cdot \text{C}_6\text{H}_4 \cdot \text{OH}$. An oily liquid, insoluble in H_2O , slightly soluble in glycerine, soluble in any proportion in alcohol, ether, and oils. It is prescribed medicinally in cases of rheumatic complaints. It is absorbed even from the hand and permeates the whole body. For rubbing, about equal amounts of salite and olive oil are used.

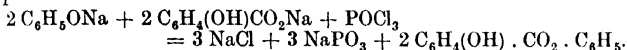
Salocoll. $\text{C}_6\text{H}_5(\text{OC}_2\text{H}_5)_2\text{NH} \cdot \text{CO} \cdot \text{CH}_2 \cdot \text{NH}_2 \cdot \text{C}_7\text{H}_5\text{O}_3$. For its preparation see "PHENOCOLL".

White crystalline needles soluble with difficulty in cold H_2O . It is prescribed as an antipyretic, antineuralgic, and antirheumatic.

In cases of fever the dose for adults is 0.5 to 1 g several times daily; for rheumatism and neuralgia, 1 g daily in 3 or 4 doses.

Salocreol. Creosote salicylate. A neutral brown oily liquid with a scarcely perceptible odour of phenol. It is used externally (painting and rubbing) in erysipelas, rheumatism, gout, &c.

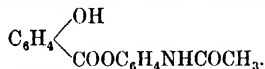
Salols. In general these are the salicylic acid esters of phenols, e. g. of phenol, naphthol, &c.; the same compounds of phenols with homologues of salicylic acid are also known as salols. More especially the name is given to phenyl salicylate $\text{C}_6\text{H}_4(\text{OH}) \cdot \text{COO} \cdot \text{C}_6\text{H}_5$. Several (in part protected) methods for the preparation of salols have been given. Salol itself is obtained by heating molecular quantities of sodium salicylate and sodium phenolate with dehydrating agents (phosphorus chloride, phosphorus oxychloride, potassium bisulphate, phosgene), certain indifferent substances like benzene, toluene, xylene being preferably added. After the reaction has taken place the "contact substances" are removed by distillation, the reaction product is washed with hot water and recrystallized from alcohol. The reaction in this process is as follows:



Salol (phenylsalicylate) forms colourless, tasteless crystals, of hardly perceptible odour. M. P. 42—43° C. It is scarcely soluble at all in H_2O , more readily in alcohol, and very easily soluble in ether and chloroform. It is an important medicament, taken internally as an antirheumatic and antiseptic; it is less disturbing to the system than salicylic acid. Dose: 0.6—1 g three to four times a day; for children 0.15 g three to four times a day. Externally it serves as a disinfectant and de-odorizer.

It is also used to a considerable extent in chemical industry.

Salophene = Acetylparamidophenylsalicylate (acetyl-p-amidosalol).



It is obtained from the nitrophenolester of salicylic acid by reduction and acetylation.

Odourless, tasteless crystalline leaves, M. P. 187—188°, scarcely soluble in cold, slightly in hot H_2O , readily soluble in alcohol and ether. It is a strong antirheumatic and antineuralgic. In cases of acute articular rheumatism it is given in doses of 6 g per diem; for nervous affections 0.5—1.5 g per diem.

Saloquinine. Quinine salicylate. $\text{C}_6\text{H}_4(\text{OH})\text{CO}_2 \cdot \text{C}_{20}\text{H}_{23}\text{N}_2\text{O}$. White, tasteless, odourless crystals insoluble in water. Prescribed as an antipyretic, antirheumatic and antineuralgic in doses of 1—2 g several times daily.

Salt (common salt; sodium chloride). NaCl . It occurs in huge deposits as rock salt, from which it is obtained by mining; further it is found dissolved in the springs coming from such deposits, in salt lakes, and in sea-water. Salt (sea salt) is obtained from sea-water either by allowing the water to evaporate in so-called salt gardens, or by freezing the water, or finally by evaporating and heating. In concentrating, Fe_2O_3 is first precipitated, then CaCO_3 , then the CaSO_4 , and as soon as the concentration 25° Bé is reached the NaCl begins to crystallize out — at first very pure (for cooking purposes), afterwards contaminated with MgSO_4 , MgCl_2 , and NaBr . If salt water is allowed to freeze the brine becomes richer and richer in salt, while almost pure H_2O crystallizes out.

Apart from the natural salt springs such are often artificially opened up by deep boring. The weak brine derived from the natural salt springs is concentrated in those lands, where the sun's heat is not sufficient for arrangements analogous to salt gardens, by means of so-called "graduator"; these latter are used especially in Germany. The graduator is a wooden structure 10—16 m high which are filled with brushwood (still better with branches of

blackthorn), and placed at right angles to the direction of the prevalent winds. The brine is pumped into the troughs running along the tops, from which it escapes and flows over the pile of brushwood. During this passage H_2O is evaporated, while at the same time the sparingly soluble constituents separate out and settle on the brushwood as "thorn-stone". The brine is allowed to pass through the gradulators 3—4 times: by this means a concentration up to 25 % NaCl is obtained. The wind also carries away a considerable amount of NaCl, — in fact the loss of salt is 20—30 % of the original amount¹).

The "graduated" brine is further concentrated by evaporation in shallow pans, $CaSO_4$ and organic substances separate out and are removed. As soon as the brine has become saturated by further evaporation it is allowed to settle a little, then drawn off into the real boiling pans, and further evaporated at about 90° C. The NaCl which crystallizes out on the surface is almost pure NaCl and is removed and dried. It is used for cooking purposes (cooking salt). The hard pan stone settles down on the bottom of the boiling pans; it consists of $CaSO_4$, Na_2SO_4 , and NaCl.

While the natural salt springs only give very weak brines, almost completely saturated brines can be obtained where it is possible to open up layers of salt by means of boring deep holes (150—300 m deep). Two copper tubes one inside the other are then driven into the salt deposit; the solvent water is allowed to flow down between the two tubes while the saturated brine is pumped up out of the inside tube. The brine is then allowed to settle and $CaSO_4$, $Mg(OH)_2$, $Fe_3(OH)_6$, and $Al_2(OH)_6$ precipitated by the addition of milk of lime. Excess of lime must be avoided, or must be removed by the addition of more brine. After the precipitate has settled, the clear brine is evaporated; this is carried out either in open pans, or *in vacuo*, or finally in closed boilers under steam pressure. In the latter case the steam (at 120°) under a pressure of about 2 atmospheres enters the hot salt solution (100° C) through a coil lying in the solution. It gives up its latent heat to the brine and becomes completely condensed. By the latter method, as well as by evaporation under diminished pressure, it is possible to use the steam (for 100 kg NaCl about 300 kg H_2O have to be evaporated) which otherwise escapes uncondensed, because at the ordinary pressure it is at the most 100° while saturated brine boils at 108°.

A problem of the greatest importance for the preparation of salt is the removal of the $CaSO_4$ from the brine. It must first be mentioned that at present the evaporation is carried out for the greater part in vacuum apparatus. In the vacuum evaporation, apparatus is employed with "double effect" and even with "triple effect". This apparatus is constructed on the barometric principle, that is, it has the form of towers the height of which corresponds to the S. G. of the liquids to be evaporated; they are open underneath, and dip into a vessel with a constant level arrangement; from this vessel the liquid to be evaporated is forced up by the air pressure into the tower from which the air is sucked out above. A steam mantle which, however, only surrounds the upper part of the tower is used for heating the apparatus: the boiling liquid floats on the cooler brine below since it is less dense. The fine-grained white salt which separates out by evaporation falls down the tower through the colder layers of brine (which are in this way heated) on to the bottom of the vessel, from which it can be continually removed (the vessel can be opened at the side). In order to construct an evaporating apparatus with double or triple effect several single pieces of apparatus are joined in the following manner: The steam mantle of the first apparatus is usually heated to 100° by the waste steam of a steam engine; in the inside

¹) The high percentage of salt in the winds coming from the gradulators makes them valuable for health purposes.

of the evaporating tower the amount of air to be removed must be so regulated that the upper parts of the brine boil at about 80° . The steam sucked off with the air from the inside of the first apparatus enters into the steam mantle of the second apparatus and raises the temperature of this to about 80° . Here the air pressure must be so regulated that the brine starts to boil at about 60° . The whole arrangement is then an evaporation apparatus with double effect; to obtain such an apparatus with triple effect the steam and air at 60° , drawn off from the second tower, are used for heating a third apparatus in which the brine boils at about 40° on account of the still further reduced air pressure.

This vacuum evaporation in the apparatus just described can only be well carried out when the CaSO_4 has been removed from the brine. Otherwise the CaSO_4 , which separates out first, forms a crust on the walls and hinders the conduction of heat from the steam mantle to the inside. The best process for removing the CaSO_4 from the brine is that protected by Germ. Pat. 118451 and several other accessory patents 140604, 140605, and 146713. In this the CaSO_4 is "salted" out of the brine by the addition of other more readily soluble sulphates or calcium salts, e. g. by the addition of large amounts of CaCl_2 or Na_2SO_4 . Traces of CaSO_4 which still remain in the brine are removed by double decomposition with BaCl_2 (if the salting out of the CaSO_4 has been done with CaCl_2), or with Na_2CO_3 (if Na_2SO_4 has been used for salting out). The Na_2CO_3 can be omitted if at the beginning caustic lime and Na_2SO_4 have been added so that free alkali is formed; in this case the filtered brine is treated with CO_2 until the free alkali has been converted into carbonate. — Germ. Pat. 142856 aims at bringing about the purification of the brine from Ca salts by means of artificial magnesium carbonate.

The drying of the salt for culinary purposes is carried out in drying pans or on hearths. See "SODIUM COMPOUNDS".

TEST. It is very important that a good average sample be taken. The qualitative tests are for potassium and then for alkali bromides and iodides, as well as in culinary salt for metallic salts (Pb, Cu, Sn). The heavy metals are tested for by the ordinary method. For the determination of the other substances mentioned a large amount of salt is treated with an amount of H_2O quite insufficient to dissolve all the salt, the resulting extract after filtration evaporated down to a third of its volume and then refiltered. One half of the filtrate is treated with platinum chloride: If KCl is present a yellow precipitate is obtained; the other half of the filtrate is treated with chlorine water drop by drop and shaken with chloroform, when first the iodine and then the bromine are set free and absorbed by the chloroform.

The quantitative test is restricted in practice usually to the estimation of water, chlorine, sulphuric acid, and insoluble matter. The amount of moisture is estimated by heating about 5 g of salt in a perfectly dry ERLLENMEYER flask of 250 ccm capacity for four hours at 140 — 150° . The total amount of chlorine

is found by a direct titration with $\frac{N}{10}$ - silver solution, using K_2CrO_4 as an indicator; from the Cl the amount of NaCl is found. The H_2SO_4 determination is carried out in the ordinary gravimetric manner.

To estimate the amount of insoluble substance 50 g of the very finely ground average sample are dissolved in luke-warm water, filtered through a weighed filter, then the undissolved substance washed without loss into a glass mortar and there ground with sufficient water to bring the whole of the CaSO_4 into solution. The water is then decanted from the mortar and the process repeated; the residue is finally brought on to the filter and dried at 100° .

After weighing, the insoluble residue on the filter is dissolved in warm dilute HCl, precipitated with NH_3 , the precipitate dissolved again in H_2SO_4

(1 : 4), and the iron oxide titrated after reduction (with Zn) with KMnO_4 solution (about 1 g KMnO_4 in 1 litre). That part of the insoluble matter which does not dissolve in HCl is washed again with H_2O and dried at 100° ; by this means the amount of sand and clay is found. If then the sum of iron oxide + sand and clay be subtracted from the total amount of substance insoluble in water, the remainder gives the amount of calcium carbonate (and magnesium carbonate).

In the filtrate from the estimation of insoluble substance in H_2O the amount of Ca and Mg can be found after the addition of $\text{NH}_4\text{Cl} + \text{NH}_3$ in the ordinary manner.

The whole of the Mg is reckoned as MgCl_2 , the equivalent amount of NaCl subtracted from the total NaCl, and in this way the real amount of NaCl is found. If more H_2SO_4 is present than corresponds to the amount of soluble Ca found, then the excess is reckoned as Na_2SO_4 , while in the opposite case the Ca-remainder is reckoned as CaCl_2 ; in this case the equivalent amount of NaCl which corresponds to this CaCl_2 must be subtracted from the total amount of NaCl.

Saltpetre (nitre). By saltpetre potassium nitrate, KNO_3 , is usually understood. The method of obtaining it from the saltpetre deposits in the East Indies (and especially in Ceylon) by lixiviation has no practical importance as far Europe is concerned. The former method of formation is losing its importance; in this process animal droppings, &c. were mixed with loose earth and allowed to stand in heaps for several years to oxidize (nitrify) after which the KNO_3 was extracted by lixiviation. The principal amount of saltpetre is now obtained from Chili saltpetre, that is, from sodium nitrate, by double decomposition with KCl. For the manufacture of such saltpetre Chili saltpetre (about 95 % NaNO_3) and Stassfurt KCl (about 80 % KCl) are employed. These are dissolved in equivalent amounts (still better with a slight excess of NaNO_3) and then evaporated. The separation of the salts present, KNO_3 , NaCl, and KCl depends on the fact that these salts have very different solubilities in cold and in hot water. For example at 0° 1 kg KNO_3 requires 7.5 kg H_2O to bring it into solution, while KCl only needs 3.41, and NaCl only 2.84 kg H_2O . On the other hand at the boiling point of the saturated solutions in question 1 kg KNO_3 is dissolved in 0.928 kg H_2O , 1 kg KCl in 1.68 kg H_2O , and 1 kg NaCl in 2.47 kg H_2O . The solutions are evaporated down till they have the S. G. 1.5, when the NaCl which separates out is constantly removed. When this concentrated solution has become clear it is brought into the crystallizing boxes where stirring contrivances cause the KNO_3 to be precipitated as a crystalline meal on cooling. The crude saltpetre thus obtained is covered once or twice with cold H_2O to remove the remains of NaCl and KCl, and is then recrystallized from boiling water.

With regard to the preparation of saltpetre from the air, see "NITRIC ACID".

Pure KNO_3 forms large transparent crystals or a crystalline powder and does not alter in the air. 100 parts H_2O dissolve at 0° 13.3 parts, at 10° 21.1 parts, at 20° 31.2 parts, at 50° 86.0 parts, at 80° 172 parts, at 100° 247 parts, and at 114° B. P. 284 parts KNO_3 . The aqueous solution has a neutral reaction and has a cooling salty taste.

KNO_3 is employed for the manufacture of gunpowder and blasting powder (see "GUNPOWDER"), for fireworks (see "FIREWORKS"), for pickling meat, in agriculture, as well as for fusions in metallurgy.

TEST. The refined saltpetre must be almost chemically pure. To determine the amount of moisture. 10 g KNO_3 are dried for two hours at 120 – 130° ; the percentage of H_2O must at the most amount to 0.25 %. To determine

the Cl, 100 g KNO_3 are treated with AgNO_3 and the precipitate of AgCl estimated by weighing. The percentage of Cl must not be more than 0.0086 % ($= 0.011 \% \text{NaCl}$).

The determination of the insoluble matter, also of Ca, Mg, SO_3 , &c., is carried out in the ordinary manner; usually a qualitative test is sufficient, 100 g KNO_3 being taken each time. To test for Na, potassium antimoniate is used.

To find the amount of KClO_3 which may be present 10 g of finely powdered saltpetre are stirred in a porcelain crucible — which is well cooled from the outside — with 25 ccm pure concentrated H_2SO_4 . The acid must remain perfectly colourless, and must not show a trace of yellow.

For the test for perchlorate see "CHILL SALTPETRE".

Sanatogen. A food preparation which has recently attracted considerable attention consisting of 45 parts caseine and 5 parts sodium glycerophosphate.

Sandarac (*Sandaraca*; *Resina sandaraca*). A resin exuding from the bark of the African fir *Callitris quadrivalvis* and solidifying in drops. The sandarac sold is pale yellow to yellow, covered with whitish dust, brittle, with a vitreous fracture. It occurs either in grains or pear-shaped drops. Aromatic, resinous, slightly bitter taste. It has a faint balsamic odour when heated. Pure sandarac dissolves in alcohol completely, giving a clear solution. It is chiefly used in the manufacture of varnishes, and of sticking plasters &c.

Sandalwood. Obtained from the *Pterocarpus santalinus* of Southern Asia. The wood is very hard, dense and heavy, and is blood-red in colour. It is sold in the form of chips or as a reddish-brown powder. Santalin, the colour principle, is a red powder. It is used for obtaining brown shades, particularly in wool dyeing, generally in combination with other dye-woods. The colour after dyeing is developed with $\text{K}_2\text{Cr}_2\text{O}_7$, alum or CuSO_4 .

Sanguinal. A preparation of blood and iron consisting of 10 parts haemoglobin, 44 parts muscle albumin and 46 parts blood salts.

Prescribed for chlorosis, anaemia, scrofula, general debility, &c., generally in the form of pills (*Pilulae sanguinalis*) which frequently contain other medicaments; also given in form of a liquid (*Liquor sanguinalis*).

Sanguis Draconis see "DRAGON'S BLOOD".

Sanofom = Diiodomethylsalicylate. $\text{C}_6\text{H}_2\text{I}_2(\text{OH})\text{CO}_2\text{CH}_3$. It is used in dressing wounds as an odourless substitute for iodoform.

Sanogen. A disinfectant consisting of a mixture of the disinfecting constituents of various tar-oils with CaCl_2 and MgCl_2 in a saponified form. Since cresosote as cresote soap is the only cresol contained in sanogen the poisonous effects of other similar disinfectants are considerably diminished. When dilute, sanogen is completely odourless. It is sold in the form of *Sanogenum technicum* and *Sanogenum medicinale*; the latter is used more especially in the treatment of wounds and as a preservative for water. It is also recommended as a manure preservative since it prevents objectionable bacterial decompositions.

Sanoleum. A mixture of crude cresols with hydrocarbons, similar to SAPROL (q. v.). It is used especially in disinfecting urinals, where it applied to the walls; it is also used to fill the syphons.

Santonine. $\text{C}_{15}\text{H}_{18}\text{O}_3$. The active principle separated from the blossoms of wormseed. It is an internal anhydride (lactone) of santoninic acid $\text{C}_{15}\text{H}_{20}\text{O}_4$.

Colourless, odourless crystals with a bitter taste, which turn yellow in the light; M. P. 170°C . ; Very sparingly soluble in cold, a little more readily in boiling H_2O , more readily in alcohol, ether, and chloroform.

Santonine has a specific action on worms. Young children are dosed with 0.025 g, older ones with 0.05 g once or twice a day. Maximum dose 0.1 g, or 0.3 g per diem.

Santyl. Santalol salicylate. $\text{C}_6\text{H}_4(\text{OH}) \cdot \text{CO} \cdot \text{O} \cdot \text{C}_{15}\text{H}_{23}$. A tasteless oil prescribed for gonorrhoea.

Saparoform. A solution of 3—5 % paraform (paraformaldehyde) in liquid potash soap, frequently with additions of aromatic substances. Said to be used medicinally.

Sap green. A concentrated decoction of the unripe berries of *Rhamnus* mixed with a little alum and indigo carmine.

Sap yellow. A vegetable dyestuff obtained from the half-ripe dried berries of various species of *Rhamnus*. The glucoside, XANTHORHAMNINE, which is present in the berries is decomposed by dilute acids giving the dyestuff RHAMNITINE. It is used in painting in the form of a lake, which is prepared by mixing the extract of the berries with a solution of alum and precipitating the aluminium lake with chalk.

Sapene. Medicine bearer, consisting of liquid soap, which according to the embodied medicament (Salicylic acid, Jod, Kreosot pp.) are indicated as Salicylsapene, Iodsapene pp. They did not irritate skin, but imbued it swiftly and give a prompt effect.

Sapocarbhol = lysol (q. v.).

Saponine. This name is given to the active constituent of the *Cortex quillajae*, or Panama bark, which is used instead of soap for washing articles of clothing, &c. It is used for producing a lather. Saponine, as well as other similar vegetable products, belongs to the glucosides. Saponine substances dissolve in water, and if the solution is well shaken or agitated a foam is produced on the water. Saponine has a biting taste and in the powdered form causes sneezing. It emulsifies with oil, and dissolves the red blood corpuscles: because of the latter property it acts as a poison. Besides being used for washing delicate materials, saponine is also sometimes employed in medical practice. To obtain the product as pure as possible the root of the plant (Germ. Pat. 116591), is steeped in H_2O and the dark-coloured extract boiled with a small addition of formaldehyde for a considerable time; it is then filtered off from the flakes of colouring matter and albumen which have become separated. The liquid is then evaporated to dryness with constant stirring. The product thus obtained forms an almost white powder, very irritating to the throat and nose. According to Germ. Pat. 144760 saponine can be prepared from horse-chestnuts. The fresh ripe fruit is opened, the nut peeled, the watery cotyledons broken or crushed and dried at a temperature of $40\text{--}50^{\circ}$. The fatty contents are then removed from the powdered nuts by means of benzine or petroleum ether and boiled several times with alcohol. The alcoholic extract is then evaporated, dried *in vacuo*, pulverised and dissolved in hot alcohol, after which the solution is treated with freshly precipitated (prepared from $\text{Pb}(\text{NO}_3)_2$ and NH_3) lead hydroxide to separate the impurities. The warm concentrated solution is poured into several times its volume of ether, when the saponine is precipitated as a white substance. The powder is then washed with ether and the operation repeated till the product is sufficiently pure. The saponine thus obtained, which should amount to 10% of the original substance, is a white powder which dissolves to any extent in H_2O and forms a frothy liquid.

According to Germ. Pat. 156954 a non-poisonous saponine is obtained from the leaves, twigs and roots of *Guaiacum officinale* or from the resin of this tree by making an extract, precipitating with lead acetate and decomposing the filtered lead precipitate with H_2S .

It should also be noted that there is a commercial article known as SAPONINE which is used as a boring and cutting oil, but which is in no way connected with the real article.

Saprol. A mixture of crude cresols and hydrocarbons, probably obtained by the distillation of petroleum.

A dark-brown liquid, lighter than water which forms a uniformly thick film shutting out the air. Used for disinfecting lavatories, urinals, &c.

Scheele's green see "COPPER COLOURS".

Scopolamine see "HYOSCINE".

Sealing wax. A substance obtained by melting shellac and turpentine with an addition of chalk, heavy spar, magnesia, burnt gypsum, bismuth white, zinc white, &c. and some colouring matter, e.g. cinnabar, English red, bone black, Berlin blue, chrome yellow, ochre, zinc chromate, lamp-black or red lead. The inferior kinds are sometimes adulterated with substitutes for shellac such as colophony, paraffin, pitch or ceresine. Some of the best qualities are perfumed with Balsam of Peru.

Shellac and turpentine are melted at a moderate temperature, with constant stirring, then the minerals are added together with the colouring matter in the form of powder and finally a further small quantity of turpentine oil is added. The liquid substance is then poured into oiled moulds.

Good sealing wax should melt readily and burn quickly; should flow and not drop; it should adhere well to paper, give clear impressions and retain its colour.

Dr. CARL GOLDSCHMIDT published an article in the Chem.-Ztg. 1905, 33, on the artificial production of shellac in which he says: "The poisonous nature of shellac renders the preparation of a cheap substitute very desirable. The formaldehyde resins are the best. The most suitable for the preparation of blue sealing wax is the resin prepared from formaldehyde, HCl and methyl-diphenylamine."

Seeger Cones. There are small tetrahedra 6 cm in height and 2 cm base composed of aluminium silicates of different melting points. The cones gradually soften when heated and the vertex falls in; a cone is said to be melted when the vertex touches the base.

Seeger cones are used in pyrometrical determinations.

The different numbers of these tetrahedra are of the following composition:

Seeger Cone No.	Chemical composition	Cal- culated tem- perature 0° C	Seeger Cone No.	Chemical composition	Cal- culated tem- perature 0° C
022	0.5 Na_2O 0.5 PbO } —	590	019	0.5 Na_2O 0.3 Al_2O_3 { 2.6 SiO_2 0.5 PbO { 1 B_2O_3	680
021	0.5 Na_2O 0.5 PbO } 0.1 Al_2O_3 { 2.2 SiO_2 1 B_2O_3	620	018	0.5 Na_2O 0.4 Al_2O_3 { 2.3 SiO_2 0.5 PbO { 1 B_2O_3	710
020	0.5 Na_2O 0.5 PbO } 0.2 Al_2O_3 { 2.4 SiO_2 1 B_2O_3	650	017	0.5 Na_2O 0.5 Al_2O_3 { 3 SiO_2 0.5 PbO { 1 B_2O_3	740

Sege- Cone No.	Chemical composition			Cal- culated tem- perature ° C	Sege- Cone No.	Chemical composition			Cal- culated tem- perature ° C
016	0.5 Na ₂ O 0.5 PbO	0.55 Al ₂ O ₃	3.1 SiO ₂ 1 B ₂ O ₃	770	7	0.3 K ₂ O 0.7 CaO	0.7 Al ₂ O ₃	7 SiO ₂	1270
015	0.5 Na ₂ O 0.5 PbO	0.6 Al ₂ O ₃	3.2 SiO ₂ 1 B ₂ O ₃	800	8	0.3 K ₂ O 0.7 CaO	0.8 Al ₂ O ₃	8 SiO ₂	1290
014	0.5 Na ₂ O 0.5 PbO	0.65 Al ₂ O ₃	3.3 SiO ₂ 1 B ₂ O ₃	830	9	0.3 K ₂ O 0.7 CaO	0.9 Al ₂ O ₃	9 SiO ₂	1310
013	0.5 Na ₂ O 0.5 PbO	0.7 Al ₂ O ₃	3.4 SiO ₂ 1 B ₂ O ₃	860	10	0.3 K ₂ O 0.7 CaO	1.0 Al ₂ O ₃	10 SiO ₂	1330
012	0.5 Na ₂ O 0.5 PbO	0.75 Al ₂ O ₃	3.5 SiO ₂ 1 B ₂ O ₃	890	11	0.3 K ₂ O 0.7 CaO	1.2 Al ₂ O ₃	12 SiO ₂	1350
011	0.5 Na ₂ O 0.5 PbO	0.8 Al ₂ O ₃	3.6 SiO ₂ 1 B ₂ O ₃	920	12	0.3 K ₂ O 0.7 CaO	1.4 Al ₂ O ₃	14 SiO ₂	1370
010	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.50 SiO ₂ 0.50 B ₂ O ₃	950	13	0.3 K ₂ O 0.7 CaO	1.6 Al ₂ O ₃	16 SiO ₂	1390
09	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.55 SiO ₂ 0.45 B ₂ O ₃	970	14	0.3 K ₂ O 0.7 CaO	1.8 Al ₂ O ₃	18 SiO ₂	1410
08	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.60 SiO ₂ 0.40 B ₂ O ₃	990	15	0.3 K ₂ O 0.7 CaO	2.1 Al ₂ O ₃	21 SiO ₂	1430
07	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.65 SiO ₂ 0.35 B ₂ O ₃	1010	16	0.3 K ₂ O 0.7 CaO	2.4 Al ₂ O ₃	24 SiO ₂	1450
06	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.70 SiO ₂ 0.30 B ₂ O ₃	1030	17	0.3 K ₂ O 0.7 CaO	2.7 Al ₂ O ₃	27 SiO ₂	1470
05	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.75 SiO ₂ 0.25 B ₂ O ₃	1050	18	0.3 K ₂ O 0.7 CaO	3.1 Al ₂ O ₃	31 SiO ₂	1490
04	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.80 SiO ₂ 0.20 B ₂ O ₃	1070	19	0.3 K ₂ O 0.7 CaO	3.5 Al ₂ O ₃	35 SiO ₂	1510
03	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.85 SiO ₂ 0.15 B ₂ O ₃	1090	20	0.3 K ₂ O 0.7 CaO	3.9 Al ₂ O ₃	39 SiO ₂	1530
02	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.90 SiO ₂ 0.10 B ₂ O ₃	1110	26	0.3 K ₂ O 0.7 CaO	7.2 Al ₂ O ₃	72 SiO ₂	1650
01	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	3.95 SiO ₂ 0.05 B ₂ O ₃	1130	27	0.3 K ₂ O 0.7 CaO	20 Al ₂ O ₃	200 SiO ₂	1670
1	0.3 K ₂ O 0.7 CaO	0.2 Fe ₂ O ₃	4 SiO ₂	1150	28		Al ₂ O ₃ 10	SiO ₂	1690
2	0.3 K ₂ O 0.7 CaO	0.1 Fe ₂ O ₃	4 SiO ₂	1170	29		Al ₂ O ₃ 8	SiO ₂	1710
3	0.3 K ₂ O 0.7 CaO	0.05 Fe ₂ O ₃	4 SiO ₂	1190	30		Al ₂ O ₃ 6	SiO ₂	1730
4	0.3 K ₂ O 0.7 CaO	0.5 Al ₂ O ₃	4 SiO ₂	1210	31		Al ₂ O ₃ 5	SiO ₂	1750
5	0.3 K ₂ O 0.7 CaO	0.5 Al ₂ O ₃	5 SiO ₂	1230	32		Al ₂ O ₃ 4	SiO ₂	1770
6	0.3 K ₂ O 0.7 CaO	0.6 Al ₂ O ₃	6 SiO ₂	1250	33		Al ₂ O ₃ 3	SiO ₂	1790
					34		Al ₂ O ₃ 2.5	SiO ₂	1810
					35		Al ₂ O ₃ 2	SiO ₂	1830
					36		Al ₂ O ₃	SiO ₂	1850
					37		.....	.....	1870
					38		.....	.....	1890
					39		.....	.....	1910

Selenium. Se. A. W. = 79.1. An element allied to sulphur, occurring in small quantities in iron and copper ores. It accumulates in the lead chambers used in the manufacture of sulphuric acid. To separate Se from the chamber mud the latter is mixed with water and Cl introduced. The Se converted at first into selenious acid and then into selenic acid is reducing by evaporating the filtered solution, heating with conc. HCl (reducing the selenic acid to selenious acid) and finally introducing SO₂ or adding NaHSO₃; the Se separates as an amorphous red powder. When heated it is changed into leaden grey, crystalline Se, M. P. 217°. The latter is insoluble in CS₂, while amorphous Se is soluble. The electrical conductivity of Se increases in proportion to the amount of light falling upon it.

According to Swedish Pat. 16359 (1903) minerals containing Se (berzelianite) are powdered and then boiled for some time with concentrated H_2SO_4 so that all the selenium is dissolved. The solution is filtered and then mixed with aqueous sulphite solution, when the selenium is again precipitated.

The preparation of Se is now of some importance as it is used for imparting a red colour to glass.

Se-compounds are analogous to those of sulphur, and their properties are much alike:—Seleniuretted hydrogen H_2Se , selenium dioxide SeO_2 (selenious acid H_2SeO_3); selenic acid H_2SeO_4 , &c.

Sepia. A colouring matter obtained from the ink-sac of the cuttle-fish (*Sepia*). The contents of the ink-sac are dissolved in NaOH and the filtered solution is precipitated with acids. The brown precipitate is, after washing, mixed with gum and moulded into tablets. It is used as a water-colour.

Sericine see "SILK".

Sesame oil. An oil obtained by pressure from the seeds of *Sesamum indicum*. The seeds are pressed first cold, then with the addition of cold water, and finally hot and in a moist state. A non-drying, pale-yellow, tasteless, pleasant smelling oil, S. G. (at 15°) 0.919 to 0.921. At -5° it assumes the consistency of butter. Saponification number 191—199, iodine number 103—110. It is used for culinary and for technical purposes.

Sewage. A distinction is made between the sewage and drainage of towns, and that of mills and other works and factories. Sewage consists of human excreta and the waste water from houses, while refuse drainage consists of the residue, waste water, &c. and from all kinds of industries. The most important to be considered here are the liquid refuse and that suspended in liquids which if kept any length of time emit unpleasant smells and cannot be stored as solid refuse is often stored. The removal or purification of drainage and refuse water is therefore of great importance for urban districts and for many branches of industry. The industries which are particularly concerned are paper mills, wool cleaning works, silk, cloth, and cotton mills, dyers' works and colour factories, sugar and starch works, breweries and distilleries, oil factories, slaughter houses, tanneries, glue factories and skinning yards. The refuse from all such trades contains much nitrogen and consists principally of organic matter. There are, however, many other branches of industry in which refuse and drainage mainly consists of inorganic substances. Among these may be mentioned coal mines, salt works, potassium chloride and bleaching powder factories, bleaching works, gas factories, soda and potash works, iron pyrites mines.

We shall give a short sketch of the manner in which the drainage from the above named works is purified, confining ourselves to the processes which are in most general use.

1. **BLEACHING WORKS.** The drainage consists, when composed of exhausted bleaching vats, principally of hypochlorous acid, while that from the neutralisation baths contains Na_2SO_4 . The first named drainage is neutralized by the second, adding lime water, and is then cleared by leaving for a considerable time to settle. After the purification the water contains CaCl_2 which is injurious to fish.

2. **BLEACHING POWDER WORKS.** The drainage contains MnCl_2 , Fe_2Cl_6 and other chlorides, HCl and uncombined Cl , besides As . The drainage can be used for seasoning wood, for disinfecting purposes, in the manufacture of glass and for the production of colours. If it is to be purified it should be done by first precipitating with a solution of alkali waste and then oxidizing with saltpetre.

3. **BREWERIES AND DISTILLERIES.** The drainage from such works varies considerably. It often contains matter which causes decay and fermentation, and in addition soluble nitrogenous compounds. Very frequently the drainage is so dilute that no purification is necessary; when necessary the waste water is conducted through irrigating hurdles or it is precipitated with lime water or with lime water and FeSO_4 . The NAHNSEN-MUELLER method protected by Germ. Pat. 31864 is much recommended. In this process soluble silica and aluminium sulphates from the refuse of alum works are used. According to Engl. Pat. 15555 (1903) the drainage is heated with CaO or $\text{Ca}(\text{OH})_2$, the sediment is then separated and employed as manure. It is not quite clear what point is here patented or where the novelty lies.

4. **CELLULOSE FACTORIES** see 13. **PAPER MILLS.**

5. **CLOTH MILLS**, see 24. **WOOL WASHING WORKS.**

6. **COAL PITS**, see 16. **SALT WORKS.**

7. **COLLIERIES.** The drainage and pit water contain coal particles, H_2SO_4 and FeSO_4 . The water is allowed to settle in boxes, and lime is also often added to combine with the H_2SO_4 and FeSO_4 .

8. **COTTON MILLS** see 24. **WOOL WASHING WORKS.**

9. **DYE FACTORIES AND DYEWORKS.** The contents of the waste water vary greatly. Besides colouring substances and pigments this drainage also contains mordants, starch, &c. Sometimes injurious metallic salts, such as Hg and As are present. There are many methods which have been put forward for purification in this case, but the only one which has proved satisfactory is precipitation with lime water. If MgCl_2 is added the result is better. The amount of chemicals added must be in proportion to the impurities present and the kind of impurity naturally determines the substance chosen. Waters containing As are best treated by precipitation with FeSO_4 .

10. **GAS WORKS.** The gas water contains large quantities of ammonium salts besides phenol and other organic substances. After the NH_3 has been obtained by boiling, the drainage is usually treated with sawdust and shavings, which are then used as fuel. Gas lime contains in addition to CaO , CaCO_3 and CaSO_4 , the sulphides, sulphates and sulphocyanides of Ca . The three last-named compounds are harmful both to fish and plants. Gas lime is used for making sulphur, for disinfecting, and for removing the hair from skins.

11. **GLUE FACTORIES.** In the drainage from bone glue factories are found glue, decaying matter and ammonium salts. The water from leather glue factories contains organic salts of lime and animal substances. It is best to use this refuse for manure; the glutinous water baths can also be employed for the preparation of superphosphates. If the refuse water is to be purified it is best to use the above mentioned NAHNSEN-MUELLER process (see under 4).

12. **IRON PYRITES PITS &c.** FeSO_4 and uncombined H_2SO_4 are found in the drainage water, besides a certain proportion of ZnSO_4 . The water is purified by precipitating ferrous hydroxide with CaO and then letting it stand in receptacles to settle; by this means the H_2SO_4 is also neutralized.

13. **PAPER AND CELLULOSE WORKS.** The waste water is contaminated with very different substances according to the material employed and the process by which the work is carried out. Organic matter in great quantities is always present and besides this there may be lime, chlorine, sulphurous and sulphuric acids. The purification is carried out in many different ways, none of which give complete satisfaction. The refuse water may be stirred with sawdust, charcoal &c. and then either burnt or distilled. The suspended semi-liquid material has also been separated by passing the drainage through metal sieves. The use of lime water has also been recommended. The NAHNSEN-MUELLER process (see under 4) also appears to be very successful for this purpose. For the methods for the preparation of manures from the waste liquors of the sulphite manufactures, compare "MANURES ARTIFICIAL".

14. POTASH WORKS, see 20. "SODA WORKS."

15. POTASSIUM CHLORIDE WORKS. The drainage water contains CaCl_2 and MgCl_2 , CaSO_4 and MgSO_4 . The chlorides are injurious to fish, but if sufficiently dilute are very favourable for the growth of plants, and can therefore be used directly for irrigation provided the amount of chloride per litre does not exceed 1 g. If the chloride contents exceed 1 g per litre the refuse water should be concentrated and treated with Cl or HCl .

16. SALT WORKS AND COAL MINES. The waste waters of such works contain much NaCl and also CaCl_2 and MgCl_2 ; in the drainage from coal mines H_2SO_4 , Fe salts, and mud containing iron oxide are in suspension.

17. SILK MILLS, see 23. WOOL WASHING WORKS.

18. SKINNING YARDS see 19. SLAUGHTER HOUSES.

19. SLAUGHTER HOUSES AND SKINNING YARDS. The drainage from such places is liquid and contains much solid matter in a state of decomposition which may be the cause of injury to health. Living disease germs, such as tubercle and anthrax bacilli, are often present. When the refuse is dried it forms a very valuable manure. Experiments have also been made, with the object of extracting the fat by means of compressed steam, and the result is said to have been satisfactory. Various kinds of reagents are used for the purpose of purifying this kind of industrial refuse. One mixture is made of carbolic acid, aluminium hydroxide and iron hydroxide; probably the NAHNSEN-MUELLER purification process will, however, be found to be the best.

20. SODA AND POTASH WORKS. The refuse from the LEBLANC process contains CaS , CaCO_3 and Ca(OH)_2 besides other sulphides, Al_2O_3 , As , &c. This dry refuse is either used as manure or worked up into other products. The drainage from the ammonia process contains much CaCl_2 and NaCl ; from these constituents HCl and Cl are obtained.

21. STARCH FACTORIES. Decomposing matter and substances which bring about fermentation are found in the waste from these industries, among others albumen, sugar, gum, and also inorganic salts. It has been found that the best means of purification is to let the water stand so that the starch can settle and then to employ the drainage for irrigation purposes. It is an excellent manure and especially so if no free acids or alkalies are present. If it is impracticable to make use of the refuse water in this way it should be purified with CaO , with CaO and Fe_2SO_4 , with CaO and $\text{Al}_2(\text{SO}_4)_3$ or similar mixtures.

22. SUGAR WORKS. The drainage contains decomposing substances and fermentation bacteria in great quantities. The most advantageous use to make of this refuse is for irrigation purposes, as the constituents which make up a good manure are present in great quantities. It is a good plan to let the drainage stand awhile until the fermentation has ended and then to clear with lime water before using in the way suggested.

23. TANNERIES. The refuse water contains decomposed matter and in some cases also disease germs. As , CaS and other harmful substances may also be present. Water may be used with advantage for damping and moistening the dry tan refuse. Putrid water is first disinfected and then cleared. Tan water is precipitated with lime or filtered through sand. If As is present the clarification must be carried out with CaO and FeSO_4 .

24. WOOL WASHING WORKS, SILK, CLOTH, AND COTTON MILLS. The vat and bath waters contain fat, oil, soap, glue, soda, alum or tartar, fuller's earth, &c. In the drainage from wool-washing there is much grease, blood, and dung. The danger from such drainage is principally due to the presence of decomposing matter. Soda and soap if exceeding 2–10‰ render water dangerous to fish. The soapy water is treated with H_2SO_4 , when the fatty acids collect on the surface and can be pressed, remelted and again pressed. The residue can then be used as manure. It is a better plan to precipitate the warm soapy water (75°) with CaO or CaCl_2 and then to use the sediment for the manu-

facture of gas for lighting purposes. Wool grease water is at present almost always used for the manufacture of potash.

In the above remarks only a few of the most common methods for the purification of drainage and factory refuse have been mentioned. The purification of town sewage will be found in the article on WATER, PURIFICATION OF.

Shale oil. A mineral oil obtained by the dry distillation of bituminous shale. (Compare SHALE TAR). From 1000 kg of shale about 135 litres of crude oil, 295 litres of ammoniacal liquor and 59 cbm of gas are obtained. The crude oil is dark-green in colour and on account of the presence of paraffin is semi-solid at the ordinary temperature: above 80° it is liquid. S. G. varies from 0.86 to 0.89. The crude oil is distilled in stills fitted with a series of bulbs placed one under the other, by which means green naphtha (S. G. 0.753) and green oil (S. G. 0.858) are separated. The fractions are treated with acids and alkalies and redistilled. The green naphtha is then ready for sale while the green oil is further fractionated into light and heavy oils. The solid paraffin, the most important constituent, is then separated from the heavy oils by cooling and pressing. The residual blue oil is used for lubricating purposes.

Germ. Pat. 159262 deals with the purification of shale oils, more particularly with reference to the removal of S. The method consists in heating the oil with dilute H_2SO_4 , then with alkalies and finally with Al_2Cl_6 ; the oil is simultaneously heated under pressure. After this treatment the oil is separated from the Al_2Cl_6 and washed. The method gives a good oil for illuminating purposes.

Shale tar. A tar obtained by heating bituminous shale with superheated steam in continuously-acting retorts, partly *in vacuo* and partly at the ordinary pressure. The product is somewhat similar to brown-coal tar (q. v.). S. G. 0.860 to 0.900. M. P. very variable.

Shellac. (*Lacca in tabulis*). The *Coccus lacca* or shell louse which lives on the branches of several plants, indigenous to India and the Southern Islands, such as *Ficus religiosa* and *F. indica*, causes by its vital processes the formation in enormous quantities of the substance known as gum lac or stick lac. This resin contains the colouring principle called lac dye. Compare "ANIMAL COLOURS". After this product has been obtained from the resin by means of water the residue is dried, melted, filtered through cloth or steel sieves, and finally poured out into thin cakes or thick pieces. This product then comes on the market in various qualities and shades under the name of shellac. It melts very readily when warmed and can be drawn out into threads which are then sold as spun shellac.

The crude product is also subjected to various processes of purification; for instance the waxy matters are separated by boiling the resinous substance with a 3 % solution of Na_2CO_3 . It is sometimes bleached by filtering through animal charcoal or through hypochlorites of sodium or potassium. Before bleaching, however, the material is swelled with a little ether, as it otherwise dissolves with difficulty in alcohol. A clear solution can never be obtained from impure shellac. A resin which dissolves completely in alcohol, is prepared by GRÄGER's method, that is by dissolving 1 part of shellac in 4 parts of alcohol (92 vol. %), and gradually adding as much distilled water as will produce a cheese-like precipitate leaving a clear supernatant fluid. It is then drained, pressed, and filtered; the pure product is obtained by distilling off the alcohol and drying the residue on a water bath.

Shellac, which is often adulterated with colophony, is used for making varnishes, cements, sealing wax, &c.

Amer. Pat. 760541 aims at the production of a substitute for shellac for polishing purposes. 9 parts of 100 % potassium-hydroxide are boiled with 140 parts of water to which are added 56 parts of a resin soluble in alcohol, and a quantity of oleic acid equivalent to 2 or 3 % of the weight of added resin; the cooled dilute mixture is then decomposed by dilute sulphuric acid and finally the precipitate is washed and dried.

Shoddy, see "Wool".

Siccatives. The name given to various substances added to linseed oil' varnish and varnish colours in order to make these liquids dry more rapidly. Siccatives are sold partly as liquids and partly in the form of powders. The former, drying oils (driers), prepared by boiling preparations of lead, manganese or zinc with linseed oil or with mixtures of linseed oil and turpentine oil, are gradually being replaced by the solid siccatives. They are the metallic salts of the same oleic, linoleic and resin acids which are obtained by evaporating drying oils or by melting the respective materials together. So, for example, resin acid salts are prepared by melting compounds of lead, manganese and zinc with colophony.

Besides these also litharge, minium, sugar of lead, lead borate, lead manganate, manganese borate, manganese oxalate, manganese dioxide &c. are used as "siccatives". Manganese borate is frequently called simply Siccative.

According to v. ZOUL (Chem. Revue 11, 80) manganese oxylinoleate is the best siccative for linseed oil. It is obtained by boiling manganese dioxide with linseed oil, or better still by neutralizing linoleic acid and then oxidizing with KMnO_4 . This siccative acts on linseed oil even when cold.

Germ. Pat. 154756 protects the addition of naphthalene in the preparation of siccatives.

The various siccatives are mentioned under the respective metallic compounds.

Sidonal. The piperazine salt of quinic acid. Obtained by neutralizing quinic acid with piperazine. A colourless salt with an acid taste, readily soluble in water. M. P. 168—171°. On account of its solvent properties for uric acid it is prescribed for gout.

Sieve machines.

Sieve cylinders and sieve machines:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Silk. Natural silk is the cocoon thread of the mulberry silk spinner *Bombyx mori*. In order to prevent injury to the cocoon by the moth crawling out the chrysalis is killed by heating the cocoons either by dry heat or by steam to 75° and then drying. To unwind the thread from the cocoon the gum which fastens the strands together is softened by dipping for a short time in boiling water; the threads of 4—18 cocoons are then spun together; on drying, the gum which was softened by the water binds the threads together to a simple strong thread. The waste parts of the cocoon yield, after boiling with soda solution, combing and spinning, the so-called floss silk.

As far as the chemical composition of the silk fibre is concerned it consists in the raw state of 86 % of real silk substance which is called fibroin, and of the silk gum surrounding the silk substance. The latter substance is similar to size and is known as sericine, silk size, or silk rubber.

Before being woven or dyed the raw silk must be freed from the coating of size; only then does it become lustrous, soft, and capable of taking up dyestuffs. The removal of the size is usually performed by treatment with

soap solution. It can be divided into the "size-removing" and "white boiling". The removal of the size is carried out by drawing the threads through almost boiling neutral soap solutions ¹⁾; after this the strands are washed in a dilute solution of sodium carbonate. If the silk free from size is not to be dyed a dark shade it must be boiled until white, that is, it is sewn in coarse sacks and boiled for about $\frac{1}{2}$ an hour in soap solution. It is then washed in a weak solution of sodium carbonate, then in pure water, and afterwards bleached with SO_2 or H_2O_2 , after which it is again thoroughly washed.

The silk free from size is termed *Cuirre*; the *cuite* silk is highly lustrous and is soft to the touch. The well known "rustling" of silk is not a natural property of the fibre, but is due to further treatment in acid dye baths.

On account of the great loss of weight suffered by the silk when the size is removed it is often preferred for many purposes to leave the silk size wholly or for the greater part still in the fibre. However, to render the silk soft the raw fibre is subjected to the so-called "soupling". In this at first a weak and only luke-warm soap bath is employed, it is then treated with sulphuric acid containing hyponitrous acid, washed and bleached with sulphurous acid; after this follows the real soupling, that is, immersion in a boiling dilute solution of cream of tartar. The souple silk thus obtained is simply raw silk rendered soft; it can be dyed both light and dark shades. To prevent it from again becoming hard on drying a further treatment is necessary, namely the so-called chevilling: for this purpose the strands are hung over a smoothly polished post (cheville) fastened on the wall, and then stroked and wound continuously by means of a polished stick, so that the point of suspension of the strands is frequently changed. Recently this work has been performed to an increasing extent by chevilling machines. In these the strands pass between several rows of revolving rollers: the rollers also make, in addition to the rotation about their axis, an up and down and also a horizontal motion, so that the strands are turned and wound under equal tension.

Finally a third kind of silk must be mentioned, namely the *écreu* or *cru-silk*. This also is a silk from which the size has not been removed—just like souple silk; but while the latter has at least been made soft, in the *écreu*-silk even this process is omitted, and the raw silk is simply washed with water, then bleached by the action of SO_2 and aqua regia, and then again washed. In soupling 8–12 % of the weight is lost, while the loss of weight by the preparation of *écreu*-silk is only 2–5 %. *Ecreu* silk is hard, can only be used when dyed dark shades, and is not used on a large scale.

Besides the genuine silk the so-called wild silk or Tussore silk (*Tasar* silk) is also used; it is spun by the caterpillar of the butterfly *Antheraea mylitta*, has a lustrous bright brown colour, is thicker than the fibres of genuine silk, and is very durable.

The average amount of water in silk is 11 %; as it can absorb up to 30 % of its weight without appearing wet the estimation of the water is of the greatest importance in the silk trade. This is carried out in the so-called conditioning apparatus; in all the more important places where silk is worked there are institutes which carry out the estimation of water in silk (as well as in wool) by means of special apparatus.

Silk, artificial. That which is now known as artificial silk usually consists of cellulose or cellulose derivatives; it is in reality more closely related to cotton than to silk, which consists of fibroin, an albumoid.

THIELE distinguishes the following classes of substances, the solutions of which are used for the preparation of artificial fibres:

¹⁾ The soap baths saturated with silk size are called "boiled-off baths", and find large employment in silk dyeing.

1. The different nitrocelluloses, partly mixed with resins, oils, fish-glue, &c. in various suitable solvents (collodion silk).
2. The esters of cellulose with organic acids especially with acetic acid (acetate silks).
3. Cellulose xanthogenate (viscose silk).
4. Solution of cellulose in ammoniacal copper oxide.
5. Solution of cellulose in zinc chloride.
6. Solutions of cellulose in sulphuric acid and phosphoric acid.
7. Solution of acid cellulose in NaOH.
8. Solutions which contain no cellulose or cellulose derivatives as a basis.

The oldest kind of so-called artificial silk is collodion silk; the discoverer is CHARDONNEL. According to his patent, which is protected by Germ. Pat. 56331 and 81599, pure cotton is nitrated to tri or tetranitrocellulose (pyroxyline); the nitrated cotton is dissolved in a mixture of 60 % ether and 40 % alcohol, — it has been proved that nitrocellulose with 25 % H_2O dissolves much more readily in ether-alcohol than dry cellulose. The resulting collodion solution (15—20 %) is brought into a closed copper vessel out of which the viscous collodion is pressed under high pressure through narrow glass tubes (capillaries); the fibre passes out under water and is there stretched, by means of suitable arrangements, to the thickness of natural silk. The collodion here becomes harder and harder as the solvent is absorbed by the water; this hardening and abstraction takes place the more quickly, the thinner the thread is. The drawn-out silk threads are continually wound on a winder, and after a certain number of revolutions taken off and dried. After drying it is washed, twisted and finally denitrated.

The denitrating (see "DENITRATION") lessens the inflammability of the collodion silk to a very great extent, and is of practical importance. Before a method had been found for denitrating nitrocellulose silk this product was much too inflammable and explosive to find its way into commerce.

The denitration is carried out according to Germ. Pat. 56655 with ammonium sulphide (ammonium sulphhydrate) or other alkali sulphhydrates, according to Germ. Pat. 125392 by means of a hydrochloric acid solution of cuprous chloride, according to Germ. Pat. 139442 with an ammoniacal copper chloride solution, and according to Germ. Pat. 139899 by means of solutions of cuprous salts in alkali chlorides; other denitrating processes are of less importance. To render artificial silk non-combustible it has also been soaked in ammonium phosphate solution.

Among the improvements on the subject of the manufacture of nitrocellulose silk may be mentioned Germ. Pat. 135316, according to which a mixture of acetone, acetic acid, and amyl alcohol is employed for dissolving nitrocellulose. The transparency of the product obtained from the solution is said to be caused by the amyl alcohol. The following proportions are given: 540ccm acetone, 310ccm amyl alcohol, 150ccm acetic acid, to bring 200 g nitrocellulose into solution. According to Amer. Pat. 699155 pyroxyline with 25—30 % H_2O is not employed but a product with 6—10 % H_2O ; this is perfectly stable if kept in a cool place. LEHNER's artificial silk belongs to this class. It is protected by Germ. Pats. 55949, 58508, 82555 &c. For improvements see also Germ. Pat. 168173, 171639, 171762 and French Pats. 361690, 361960 and 372889.

Shortly after the collodion silk was discovered cellulose silk also began to be manufactured. (THELE silk) As a solvent for cellulose ammonia copperoxide or zinc chloride was principally employed (Germ. Pat. 98642, 109996, 119098, 119099, 118836, 118837, 119230, 121429, 121430). Pure cellulose (cotton wool) is freed from fat, and then dissolved in ammoniacal copper oxide. The further treatment is the same as with the pyroxyline solution, only that the vessel surrounding the capillaries is filled not with H_2O , but with dilute acid which

dissolves $\text{Cu} + \text{NH}_3$ and the fine cellulose thread separates out. According to Amer. Pat. 672946 the cellulose is dissolved in ammoniacal copper oxide in the presence of free copper hydroxide; the solution of the cellulose is accelerated if this has been previously treated with strong caustic potash.

The manufacture of cellulose silk has been subject to many improvements. In the first place Germ. Pat. 154507 and 157157 may be mentioned; according to these the concentrated ammoniacal copper oxide cellulose solution is allowed to enter through wide openings into a precipitating liquid which acts very slowly, and here drawn out to fine threads. Such liquids are water, ether, acetic ether, benzene, chloroform, carbon tetrachloride, &c.; over this liquid another is poured which brings about a vigorous decomposition of the cellulose solution. The process is said to give a very fine and much firmer and more elastic thread than is obtained in other ways.

Germ. Pat. 162866 protects a modification of the process of dissolving cellulose in ammoniacal copper oxide. French Pat. 347960 and Amer. Pat. 779175 precipitate the cellulose from the copper oxide solution, not with acids, but on the contrary with alkalis.

See also Germ. Pats. 169567, 173678, 174508, 175296 and supp. 185139, 178942, 179772, 183153, 183557 and Supp. 187313, 184150, 185294, 186387, 187263, French Pat. 373088, 373429, Amer. Pat. 806533. The process of French Pat. 323475 is very interesting; it consists in dissolving acid cellulose (hydrated cellulose) in sodium hydroxide. The cotton is first treated with ten times the amount of H_2SO_4 S. G. 1.55 and then the mass brought into a large volume of water, the resulting hydrated cellulose (vegetable parchment) is washed and dissolved in NaOH S. G. 1.12. The cellulose is precipitated from the solution with acids, and can then be spun in the known manner. If this process can be rendered practicable it will certainly be the cheapest for the production of artificial silk.

Another kind of artificial silk is the so-called viscose silk, which is made according to Germ. Pat. 108511 from the soluble cellulose xanthogenate. The viscose possesses the property of dissolving in water to form a slimy liquid; for the manufacture of artificial silk this solution is pressed through capillaries, and the issuing threads pass into a solution of ammonium chloride. The viscose is here decomposed and a cellulose thread remains, but in order to finish the decomposition the strands must be further treated with boiling NH_4Cl solution. If the viscose is purified according to Germ. Pat. 133144 before solution, the silk prepared from it is much more valuable. See also "VISCOSE".

Also another kind of artificial silk is the so-called "acetate" silk, that is, cellulose acetate. For the preparation, see "CELLULOSE ESTERS". As this product, unlike collodion silk, is non-combustible, and does not need to be denitrated, it has a much greater hardness. It is expected that the acetate silk, which has only recently been brought into commerce, will become of great importance.

Gelatine silk, also termed vandura silk, has not been introduced commercially: it is prepared according to Germ. Pat. 88225 from gelatine and formaldehyde.

Various other processes for preparing artificial fibres have not obtained any importance, e. g. Germ. Pat. 148587, which takes as a starting point gelatinous vegetable substances (Agar-Agar, sea-weed, Irish moss, &c.) which are soluble in hot water, and insoluble in cold H_2O .

Some modern investigations are not without interest. Fibres are obtained from an alkaline solution of caseine, another solution forced in thread form into an acid liquid (Germ. Pat. 170051, suppl. Germ. Pat. 178985 and Germ. Pat. 182574). Another process due to the same inventor is the forcing of a solution of caseine in ZnCl_2 into a bath in which the fibre is hardened.

Artificial silk is hardly inferior in beauty to natural silk; it can also be dyed with excellent results. On the other hand, its firmness and durability are, up to the present, much less than those of natural silk.

In the same way stronger spun-fibres, &c. have been prepared, thus for instance artificial horse hair is now being more and more brought into notice: it is made according to Germ. Pat. 125309. The Germ. Pat. 129420 is a newer process with the same object; according to this threads of cellulose or cellulose derivatives are drawn through suitable solvents in which the single fibres of the thread are so softened or dissolved that they unite together to a single perfectly homogenous thread with a smooth and polished surface. This thread is then drawn through suitable solidifying solutions or allowed to harden in the air. See also Germ. Pat. 181784 and 186766 and Amer. Pat. 856857.

Finally it may be mentioned that cellulose threads have also been used as artificial human hair (for wigs) for this purpose. The threads have only one fault, they have too much lustre. This drawback is removed by several processes (Germ. Pat. 129420 and 137461.)

The preparation of artificial hemp bast by steeping these fibres in collodion, viscose or dissolved cellulose to which substances such as heavy spar, chalk zinc white are added is protected by Germ. Pat. 184510.

According to E. HERZOG artificial silk finds its chief employment in the trimming and lace industry for the preparation of glittering braids, lace and borders for ladies' clothing.

While these articles up to about 4—5 years ago were prepared exclusively on the plaiting machines, bands are now manufactured in great quantities from artificial silk on the Jacquard weaving looms. Further, insertions are manufactured from artificial silk which, sewed together with silk bands or strips, yield stuffs for blouses, ladies clothes, ties and wearing apparel generally. The manufacture of carpets and decorative furniture stuffs from artificial silk appears to have a very promising future. Comparing such stuffs with real silk, artificial silk possesses, the advantage of being readily freed from adhering dust. The latest industrial use of artificial silk is the preparation of incandescent lighting mantles. These are said to be more elastic and to possess a greater and longer incandescent power than the others.

The production of artificial silk in 1905 amounted to more than 1 million kg representing a value of at least $1\frac{3}{4}$ millions sterling. The present value is probably about $2\frac{1}{2}$ millions.

TEST. The methods for detecting the presence of artificial silk in textures are becoming increasingly important. One of the most certain methods for distinguishing artificial silk from natural silk or from mercerized cotton in the texture is the following. The stuff to be tested is heated for 10 minutes to 200°. After this time the artificial silk is still intact as far as the structure is concerned, but is completely carbonized, so that it falls to pieces on being touched. Cotton, wool, and natural silk remain on the other hand unaltered and show hardly any trace of a brown or black colour. If the heated cloth is rubbed after it has cooled sufficiently, the artificial silk is removed as dust, and by comparing with another piece of the original cloth it can be exactly determined which and how many threads consist of artificial silk. Single artificial silk effect threads, can be detected with great certainty in this manner, and infallibly distinguished from natural silk.

According to A. HERZOG the polarisation microscope may be used for distinguishing natural from artificial silk. When seen under this, dyed natural silk does not appear dichroic. Coloured cellulose artificial silks are on the other hand strongly dichroic, especially those which are dyed with congo red, benzoazurine, or methylene blue.

Silk dyeing. The affinity of the animal fibres for most of the dyes is much greater than that of cotton for the same dyes. The information given under "WOOL DYEING" applies generally speaking to silk. Apart from that, we must here mention the "chevilling" and the "lustreing", two operations, which are only used in silk dyeing.

The dyed silk strands are chevilled to give them an increased softness and a certain "handle". For this purpose the strands are hung over a smoothly polished post (cheville) on the wall, then stretched and wound continuously by means of a similarly smoothly polished stick, the point of suspension of the strands being thus frequently changed. Of late years more of the work is being done by chevilling machining (glossing machines). Here the strands pass between several rows of revolving rollers; these rollers, apart from turning round on their axes, have also an up and down and a horizontal motion, so that the strands are turned and wound under equal tension.

Lustreing has the object of increasing the shine of the dyed silk and of stretching curly fibres. In the lustreing machines rollers come into play and work up the strands, but these are in a closed case with the rollers into which steam passes during the operation.

Everything else with regard to silk dyeing corresponds, as said before, to wool dyeing. The mordanting of the silk is carried out similarly to that of wool, only high temperatures are avoided: Metallic salt solutions, with which the silk is treated to mordant it, do not require (as in wool dyeing) high temperatures, but rather decompose by simply washing with water, in which operation the hydroxide or basic salt is fixed on the silk fibre.

By this process silk becomes heavier. This extra weight is, when carried to excess, an adulteration, but it has become a custom sanctioned by time.

A certain extra weight must of course result as soon as the silk is dyed with the help of the important metallic mordants. It was at first only intended to replace the loss suffered by the silk when the gum was removed. This was quite successful in the case of black silk as the dyeing with log-wood rendered the employment of heavy metallic mordants necessary. Finally step by step stronger mordants were used, the mordanting repeated several times, &c., and in the end an increase in weight was attained which more than compensated for the loss of weight due to the removal of the gum.

It was, however, much more difficult to bring about an increase in weight in the case of bright coloured silks. Finally it was suggested that the silk after dyeing should be dipped into sugar solution, which not only caused a direct increase in weight but also imparted to the silk the capability of absorbing more moisture from the air. Nowadays "Weighting" by means of sugar is being gradually replaced by treatment with tannic acid, which is carried out simultaneously with the dyeing. In this way an increase in weight of 15—20% of weight of silk is attained without any loss of the other properties. To attain a greater increase in weight tannic acid is combined with a metallic salt, especially a tin salt, and the greatest increase in weight is attained by using tin compounds alone, at the cost, however, of the durability. If tin chloride and sodium phosphate are used, an increase in weight of 100—300 % can be attained.

Silicides. Silicon (q. v.) combines when heated in the electric furnace with many metals to form silicides which are in various respects very similar to carbides (q. v.). Silicides are distinguished by their special hardness, a feature which should provide a wide industrial field. The following may be mentioned: chromium silicide SiCr_2 , manganese silicide SiMn_2 , iron silicide SiFe , and copper silicide SiCu_2 . Silicides are produced partly by fusing the respective metals with silicon in the electric furnace, partly by heating mixtures of silica, me-

tallic oxides and carbon. It is worth noting that silicon frequently combines with metals at a temperature below the fusion point of either.

Silicon carbide, see "CARBORUNDUM".

Silicon. Si. Atomic weight = 28.21. The element which next to O forms the greatest part of the earth's crust, never occurs in the free state, always either as SiO_2 (see "SILICON COMPOUNDS") or in the form of silicates. The element itself may be obtained by reducing SiO_2 dust with magnesium powder and extracting with acids. In this way the product is an amorphous, dark brown, loose powder which ignites in contact with the air. Crystalline (diamond-like) Si is obtained by heating potassium silicofluoride K_2SiF_6 with Al, or by placing a mixture of 15 pts. Na_2SiF_6 , 20 parts granulated Zn and 4 parts Na in a red hot fireclay crucible, or by reducing quartz with charcoal, CaO and Mn_2O_3 in the electric furnace; the reaction mixture is freed from foreign substances by extraction with HCl and HF. According to Amer. Pat. 732410 Si is obtained from aluminium silicates (e. g. common clay), by mixing with powdered metallic Al and subjecting the mixture to high temperatures in electric or other furnaces; the product is Si and an aluminium oxide slag. According to Germ. Pat. 147871 crystalline Si is obtained by igniting a mixture of an oxygen compound of silicon with aluminium powder and sulphur: The mixture begins to burn, and aluminium sulphide is formed. This fuses and Si is found imbedded in the melt; it is obtained by decomposing the Al_2Si_3 with H_2O .

Crystalline Si forms bright black leaves or hard and brittle octahedra which remain unchanged in air though it is converted into SiO_2 by the action of CO_2 . Insoluble in acids, soluble in hot concentrated potash lye and soda lye.

Silicon is chiefly used in alloys with Cu, Sn and Zn, as silicon bronze (see "BRONZES"); Si is added to the bronze in the form of aluminium silicide or copper silicide. The former is produced directly by the electrolysis of aluminium silicate, the latter by fusion of Cu with SiO_2 and NaCl.

Silicon compounds.

1. **SILICON DIOXIDE.** SiO_2 , also called silicic acid, occurs naturally as quartz and tridymite, amorphous as opal; quartz is the most important and most widely distributed form. SiO_2 in crystals is prepared artificially by decomposing glass and other silicates with H_2O under pressure at a temperature of 300–400° C; amorphous SiO_2 by heating silicates to a very high degree. For vessels of fused silica, see "QUARTZ GLASS".

Silicic acid itself is obtained by evaporating the solution of sodium silicate (or potassium silicate) with HCl, and treating the residue with H_2O . The product is a jelly-like precipitate.

2. **SILICON FLUORIDES.** Especially important is sodium silico-fluoride Na_2SiF_6 . It may be prepared by saturating H_2SiF_6 with NaOH or Na_2CO_3 , or from common salt and H_2SiF_6 . Recently large quantities have been obtained as by-products in the manufacture of superphosphates.

3. **SILICON BRONZE**, see "BRONZES."

4. **SILICON CARBIDE**, see "CARBORUNDUM".

5. **SILICIDE, COPPER**, see "SILICON".

6. **FERROSILICON**, see "IRON ALLOYS".

7. **SILICATES** see under respective metallic compounds; **WATERGLASS**, see special article.

Silene. A compound of hexamethylenetetramine, citric and silicic acids. Used in cases of uric acid troubles.

Siloxicon. An automatically hardening fire-proof material which resists the action of alkalis and acids, insoluble in molten iron and slag. It is used to make fire-proof bricks, muffles, pipes, crucibles, furnace linings, &c. The composition is approximately $\text{Si}_3\text{C}_2\text{O}$. It is made, according to Amer. Pats. 722902 and 722903 by heating powdered silica with a small amount of carbon in electric furnaces. The amount of carbon must be less than that used in producing carborundum (q. v.).

Silver. Ag. A. W. = 107.93. It is usually found native. The most important ores are silver glance, Ag_2S ; copper silver glance, $\text{Ag}_2\text{S} \cdot \text{Cu}_2\text{Si}$; antimony silver blende $\text{Sb}_2\text{S}_3 \cdot 5\text{Ag}_2\text{S}$ and $\text{Sb}_2\text{S}_3 \cdot 3\text{Ag}_2\text{S}$; arsenic silver blende, $\text{As}_2\text{S}_3 \cdot \text{Ag}_2\text{S}$; polybasite $\text{As}_2\text{S}_3 \cdot 9(\text{Ag}_2 + \text{Cu}_2)\text{S}$ and horn silver AgCl . Silver is also obtained from fahl ore (particularly from antimony fahl ore).

Silver is obtained by dry or wet methods, frequently by a combination of the two.

Formerly the only dry method employed was that involving the use of lead; now, however, the amalgamation process and in particular the extraction process are widely used.

In working silver ores by the dry method the ores are melted with Pb or PbO. The silver in the compound is replaced by lead ($\text{Ag}_2\text{S} + \text{Pb} = \text{PbS} + 2\text{Ag}$) and remains dissolved in the excess. A work-lead containing silver is thus obtained. If the lead is rich in silver it is submitted to the process or cupellation. This consists in exposing the fused alloy to a current of oxidizing gases, the temperature being constantly raised. The whole of the lead is oxidized to PbO which accumulates and finally runs off from the silver which appears bright (flashes). The silver is finally remelted in a porous muffle when the oxidized impurities are absorbed by the muffle.

If the work-lead is poor in silver it is first subjected to the PATTINSON process. This process consists in melting the alloy in iron pots and cooling slowly. Practically pure lead first crystallizes and can be readily removed from the more easily fusible and still liquid Pb—Ag alloy. The latter which is now richer in silver is again melted and the above process repeated. Very pure lead is obtained on the one hand and an alloy rich in silver on the other. A modification of this is the PARKES process. To the fused alloy (at 450°) zinc is added and the molten mass well stirred. A layer of zinc containing all the silver and a little lead rises to the surface on cooling and can then be easily separated. The Ag—Pb—Zn alloy is subjected to cupellation. Various modifications of these processes have been introduced.

The amalgamation process depends upon the formation of a silver amalgam with mercury. It is well adapted to certain kinds of ore. The native silver of the ore combines directly with the mercury while the silver compounds must be first reduced to the metallic state. The ore is roasted with NaCl and the AgCl reduced with iron: $2\text{AgCl} + \text{Fe} = \text{FeCl}_2 + \text{Ag}$. Hg is then added which takes up all the silver. The amalgam is heated in retorts, the mercury distils over and metallic silver is left.

In the extraction process a method similar to that used in the preparation of copper is adopted (see "COPPER"). The Ag ore is either roasted with alkali chlorides when AgCl is formed, or it is roasted and heated with H_2SO_4 with formation of Ag_2SO_4 . The AgCl is dissolved in NaCl solution or the Ag_2SO_4 in water and from these solutions the Ag is precipitated with copper (cf. "GOLD"). Hyposulphites are also used for the extraction of silver, and quite recently the cyanide process as used in the metallurgy of gold has been successfully adopted.

Copper is now de-silverized by an electrolytic process (for the MOEBIUS method see GOLD). Amer. Pat. 795887 protects a method for the electrolytic refining of bismuth containing Ag.

Silver is a pure white metal, very ductile and the best conductor of heat and electricity. S. G. 10.4 to 10.6. M. P. 968°. It can be distilled in the oxygen-hydrogen flame. The vapour is of a blue colour. Pure fused silver absorbs 20 times its volume of oxygen from the air. This is given off on cooling ('spitting').

Silver has recently been obtained in a water-soluble form, or more correctly, in the colloidal state. (See COLLOIDAL SUBSTANCES). In addition to the methods there described the method of KUESPERT may be mentioned (Ber. d. deutsch. chem. Ges. 35, 4066 and 4070).

According to this method reddish-brown solutions of colloidal silver may be obtained by adding a solution of AgNO_3 to a concentrated solution of water-glass containing formaldehyde. Olive-green to pale-green colloidal solutions may be prepared from dilute AgNO_3 solutions by first neutralizing with Na_2CO_3 and then adding hydrazine hydrate (1 : 2000). With the help of lysalbinic and protalbinic acids colloidal silver may also be obtained.

For the use of colloidal silver as a medicament see, "COLLARGOL".

Ag quickly becomes coated with a brown film of Ag_2S when exposed to an atmosphere containing H_2S . It is readily soluble in dilute HNO_3 . On account of its softness it is only used in the pure state for making chemical apparatus crucibles, dishes, &c.)

See also PLATING, SILVER ALLOYS, SILVER PLATING.

For oxidized silver, see "METALS, COLOURING OF".

Silver:

Johnson, Mathey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Silver alloys.

On account of its softness silver is always alloyed, usually with copper. For English coinage the alloy has a fineness of 925, i. e. it contains 92.5 % Ag, 7.5 % Cu. In Germany the fineness is 900.

Silver of a fineness 900 is used almost universally for medals, ornaments, &c. The percentage of copper is often greater when the metal has to be cast. Alloys containing 50 % of copper are fairly white, but have a reddish tinge. Such alloys are given a thin white coating by first heating in the air and then dissolving the coating of CuO formed in a solution of NaCl and cream of tartar.

Silver does not alloy very readily with copper, nor does the addition of this metal do away entirely with the property of "spitting". An addition of varying amounts of Zn and Cd is made to prevent "spitting".

In order to give a silver-white colour to alloys containing much copper, aluminium and nickel („see NICKEL ALLOYS") are added.

Silver compounds.

1. **SILVER CHLORIDE.** AgCl . Occurs native as horn silver. Prepared by precipitating AgNO_3 solution with HCl or NaCl . When washed and dried it appears as a white amorphous powder insoluble in H_2O , HNO_3 and HCl , soluble in NH_3 , turning black by reduction when exposed to the light. It melts at 260° solidifying as a colourless, horny mass (horn silver).

2. **SILVER IODIDE.** AgI . Occurs native as iodargyrite. Prepared by precipitating AgNO_3 solutions with HI or alkali iodides. A pale yellow powder insoluble in water and dilute acids, soluble with difficulty in NH_3 , readily soluble in concentrated KI solution.

It melts on heating and solidifies to a pale-yellow horny mass.

3. **SILVER NITRATE**, see "LUNAR CAUSTIC".

4. **SILVER SULPHATE.** Ag_2SO_4 . Obtained by heating silver filings, or reduced silver (from AgCl and $\text{Zn} + \text{HCl}$) with H_2SO_4 and evaporating until the solution crystallizes.

Small, colourless, shining crystals, soluble in 200 parts of water (at 15°), in 70 parts H₂O (at 100°), more readily soluble in water acidified with HNO₃ or H₂SO₄.

Silver compounds:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Silver nitrate:

Johnson's, Cross St., Finsbury, London.

Silver Plating. Plating by heat (cf. GILDING) has now but little importance. Electroplating (q. v.) is the most important method. Solutions of AgCN in excess of KCN.

SILVER BATHS¹⁾. No. I is for ordinary plating, No. II for heavy plating with a battery, No. III for heavy plating with a dynamo.

	I	II	III
Silver nitrate	170	340	425 grammes
In distilled water	5	5	5 litres
Add a solution of pure (99 %) KCN	260	520	650 grammes
In distilled water	5	5	5 litres
The bath contains per litre ..	10.8	21.6	27 grammes Ag

Silver foil is used for the anodes. Current 0.25—0.35 amp. per sq. dm at 0.5 to 0.75 volts. For new baths to every 10 litres a solution of 20 g potassium formate, 4 g ammonia (S. G. 0.96) in 100 g dist. water is added.

Copper articles should first be „quickened”, i. e. dipped in a 0.1—0.2 % solution of HgNO₃. This is particularly necessary where heavy plating is to be done. Articles of iron, steel, nickel, tin, Britannia metal and lead are first coated with Cu and then silvered (sometimes after a previous „quickening”).

Silver plating:

Cannings. Great Hampton St., Birmingham.

Siroline. A liquid medicament, consisting of 10 parts Thiocoll (q. v.) in 140 parts orange syrup.

Given internally for whooping cough, colds, lung diseases &c.

Slags. Glass- or enamel-like residues occurring in most ore smelting processes. As a rule they are compounds of SiO₂ with various bases (silicate slags), or metallic oxides containing smaller quantities of SiO₂. The formation of the slag protects the metals formed by reducing processes in the smelting, from further oxidation.

Slags are utilized in various ways, the structure, hardness, &c. being of importance. Acid slags (containing much SiO₂) are made into bricks (small pieces of these slags are mixed with slaked lime and moulded into bricks;) powdered slag is used instead of sand for making mortar, also in iron foundries for making moulds and finally also in glass works. Blast furnace slag (see “Pig Iron”) is used to make cement, putty, alum, and as a manure.

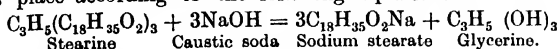
Slag wool, formerly much used as a non-conductor of heat and obtained by blowing air or superheated steam into the molten slag is rarely manufactured now. The slag used had to be blast furnace slag and to contain little basic substance. The result was a fine thread-like soft mass, like cotton wool.

Thomas-slag, important as a manure, is obtained in the Bessemer process. The methods of using Thomas-slag for preparing manures is treated under “MANURES, ARTIFICIAL”.

¹⁾ Steinach and Buchner, Die galvanischen Metallniederschläge.

Smalt see "COBALT COLOURS".

Soap (*Sapo*). The fats and oils are glycerides of fatty acids which are decomposed by the action of caustic alkali into glycerine (q. v.) and the corresponding salts of the fatty acids; the salts of fatty acids are termed soap and the process of decomposing the fats into glycerine and soap is known as "saponification". Thus the saponification of the real stearine — the glyceride of stearic acid (technically very often simply called stearine) — takes place according to the following equation: —



The potassium soaps are the easiest to make, sodium soaps are somewhat harder, while those of lime, baryta, lead oxide, &c. are much more difficult. In saponification the concentration of the lye plays an important part; usually the caustic alkali must contain some alkali carbonate in order to ensure complete saponification. On the other hand the carbonate by itself is not sufficient.

For the manufacture of soap, coconut oil, palm oil, palmkernel oil, suet, wood oil, sesame oil, earth-nut oil, cotton oil, linseed oil, blubber, hemp oil, and oleic acid are used; the last is a by-product in the manufacture of stearic acid. Pine resin is used as an addition; soaps from pure resin do not become hard, but on the other hand they cannot be used as soft soaps. The lyes are prepared partly by dissolving NaOH or KOH in H₂O; Na₂CO₃ or K₂CO₃ solutions are also prepared and the soda (or potash) decomposed with the help of caustic lime. A little less lime is added than the amount required to convert the carbonate into caustic alkali, so that a small amount of carbonate is still present, as this has a favourable influence on the formation of soap. The different fats require approximately equal amounts of alkali, 13.5—15 parts NaOH or 19—21 parts KOH being mixed with 100 parts of fat.

The saponification is brought about either by gently boiling in an iron boiler over a free fire, or by means of steam heating.

Of late years the so-called carbonate saponification has become of greater importance. The fats are first decomposed in digesters (see "FATTY ACIDS"), and the resulting fatty acids neutralized—not with caustic alkali—but with alkali carbonate, that is, with Na₂CO₃ or K₂CO₃. The carbonate saponification is more convenient and cheaper, and at the same time allows the glycerine to be used.

The process of the fermentative decomposition of fat is quite new and is perhaps destined to revolutionize the whole soap industry. For fuller information about this fermentative fat decomposition, also called "Fat decomposition by Enzymes", see "FATTY ACIDS".

In the modern soap industry efforts seem to be directed towards removing the glycerine from the fats before converting them into soap, that is to separate them into fatty acid and glycerine, to separate the latter, and then neutralize the acid. The interesting process of KREBITZ (Germ. Pat. 155108) is based on this principle: The fats are mixed at 100° with slaked lime and H₂O when glycerine water and insoluble loose lime soaps are formed. Instead of the lime other oxides which form insoluble soaps can be used. The lime soaps are crushed, lixiviated again with hot water to obtain the glycerine, and finally boiled directly with soda solution; CaCO₃ is precipitated and a soap solution formed.

Finally the peculiar fat decomposing process of E. TWITCHELL may be mentioned. Here the fat is decomposed by boiling in open boilers with steam with the addition of a fat decomposing agent discovered by the inventor; this agent is, according to investigations, benzene stearyl sulphonic acid C₈H₄(HSO₃)(C₁₈H₃₅O₂)₂.

When the saponification process is finished the soap mass is allowed to solidify in large cooling boxes (moulds); instead of the wooden moulds formerly used, which could be taken to pieces, cast iron ones — which can also be taken to pieces — are coming more into use. The soap blocks thus obtained are cut into bars with steel wire; this is now, however, usually carried out with suitable cutting machines. Further, kneading presses and moulding presses are in use, and serve for the manufacture of fine toilet soaps. For this purpose a good ground soap mass is crushed, ground further in so-called „pilier“ machines, mixed with perfume and dyes, brought into the kneading press, where it is strongly pressed and then brought into the required form in the moulding press.

The details of soap manufacture are very numerous and vary according to the nature of the product to be prepared.

The best soaps are the grain soaps; especially the tallow grain soaps. They are prepared by saponifying with pure NaOH, adding ordinary salt until the soap is obtained in a flaky state; it is then further boiled until the soap runs together, and is finally allowed to solidify in moulds. The concentration of the lye, the method of boiling, &c., are of particular importance. If the mass which has been poured hot into the moulds is stirred until it begins to solidify homogeneous soaps are obtained, while if allowed to stand without stirring „mottling“ takes place (through the impurities present). By adding dyes the mottling can be increased. To avoid mottling and at the same time to remove the impurities the grain soap is polished, that is, after it has boiled clear a little more H_2O or NaOH is added: with this amount of water, if allowed to cool slowly, the palmitine and stearine soaps crystallize out from the oleine soap which retains the impurities. Apart from tallow, sesame oil, palm oil, cotton oil, and olive oil are worked up into grain. The Marseilles soap is well known, and is used in silk dyeing; this soap is also known under the names olive oil grain soap, Spanish soap, and Venetian soap. Further, grain soap is also prepared in large quantities with the addition of resin because the resinous grain soaps are cheap, can be readily saponified, and lather well. Palm oil can be very easily saponified, and for this reason the manufacture of palm oil grain soaps is becoming more important.

The grain soaps are alkali salts of fatty acids from which the other constituents have been removed, while the filled soaps comprise the whole contents of the boiler; they contain besides the real soap also the other components. Filled soaps are weighted on a very large scale, alkali carbonates, talc, clay, cryolite, flour or water-glass being employed for this purpose. The filled soaps are nearly always prepared from cocoa nut oil which can be readily saponified but only with strong lyes. It yields a soap which combines with 50—70% H_2O without in any way losing its hardness. The half-grain soaps stand between the grain soaps and filled soaps, and are also termed ESCHWEGER soaps. They show good marbling, and are hard and dry, but also contain a large amount of water; they can only be prepared with the help of cocoa-nut oil or palm nut oil. They can be made by boiling a filled soap made from the latter oil and adding this to a grain soap obtained from tallow. This indirect method yields a very good article, but a more convenient and direct method is to boil tallow, &c. together with cocoa nut oil or palm oil; the direct method is used exclusively for earth-nut oil, linseed oil, oleine, and cotton oil. When the soap mass is well set waterglass is added.

Sodium soaps can be made entirely in the cold from cocoa-nut oil as well as from palm nut oil if concentrated NaOH (38° B \acute{e} .) be employed. The saponification takes place afterwards in the mould on account of spontaneous heating. In this process a certain percentage of fats saponifiable only with, difficulty such as dripping, tallow, olive oil, &c., can be added to the mass,

and these also take part in the saponification. In this way white solid soaps are obtained which can be used as cheap toilet soaps.

The potassium soaps (soft soaps) are greasy, soft, and ointment-like. For their preparation, linseed oil, sesame oil, rape oil, earth-nut oil, cotton oil, tallow, palm oil, and oleine, are employed. The smooth transparent soft soaps (black, brown, and green crown soaps) are usually manufactured from linseed oil with KOH (K_2CO_3 lye treated with lime), but a certain amount of NaOH is always added to prevent the product from becoming quite liquid in summer. A certain percentage of carbonate must also be present in the lye.

Corn soap is the best soft soap and is prepared from mixtures of lard and soft fats or oils with pure potash solution; the former yield the corn, while the latter form the clear ground soap. Unless carbonate is present in the lye corn soap cannot be obtained.

Finally silver soap (elain soap) is a smooth soft soap resembling mother of pearl, which is prepared from cotton oil with the addition of tallow, pigs' lard, palm oil, &c. The peculiar appearance is caused by the fact that 20 to 30 % of soda lye (of 25° Bé) are added to the boiling potash lye. The resulting sodium soap forms white shining stripes in the potassium oil soap.

See also "METAL SOAPS", "FATTY ACIDS", "FORMALIN SOAPS", "SOAP POWDER", &c.

TEST. Testing is very important on account of the numerous adulterations. The following table (p. 612) by Leeds gives a summary of the methods of testing:

To complete the table the following may be said: —

For the water determination a small dish provided with a glass rod and about $\frac{1}{3}$ full of sand which has been previously heated is weighed, about 5–10 g of finely scraped soap added, weighed, then heated and frequently stirred in a drying oven at first for some time at 60–70° and then, when melting and the formation of a skin need no longer be feared, to 110°. The extraction with petroleum ether is carried out in a SOXHLET's apparatus. For the determination of the fatty acids and resin the soap is boiled with excess of acid until the precipitated fatty acids swim above in a perfectly clear layer. After cooling, the solidified cake is twice broken through with a glass rod and the liquid poured off. The fatty acids can be purified by remelting with water, after which the cake is removed and dried. The percentage of fatty acid found, minus 3.25 %, gives fairly accurately the percentages of fatty acid anhydrides.

The combined alkali is usually calculated to Na_2O (when only small amounts of potash are present) and with soft soaps the process is analogous.

For fuller information see LUNGE, *Chemisch-technische Untersuchungsmethoden*, Bd. III, 1900, and DAMMER, „*Handbuch der chemischen Technologie*, Bd. III, Stuttgart 1896.

Machines for making soap:

Werner Pfleiderer & Perkins Ltd., Peterborough.

Complete soap-plants:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Soap Cooling apparatus:

C. Harzer & Co., Finsbury Pavement House London EC.

Toilet soap manufacturing machines:

J. M. Lehmann, Dresden-A. 28, Germany (see front part advt.).

Soap colours. For half-grain soaps the following colours are used: For grey, fine animal charcoal or Frankfurt Black; ultramarine for blue, English red, bolus, marble red or cinnabar for red. The same colours (and manganese dioxide) are used for mottling grain soaps. Filled soaps are dyed yellow with

For the determination of the amount of water 5 g of soap are dried at 110°. After being weighed it is extracted with petroleum ether.				
The solution contains non-saponified fat which, after the evaporation of the solvent, is dried at 110° and weighed.	The residue consisting of soap, glycerine, mineral matter, &c., is treated with absolute alcohol.			
	The solution contains soap, glycerine, and free alkali which is determined by titrating with normal H_2SO_4 after the addition of phenolphthalein. After the addition of a large amount of water and evaporation of the alcohol, the soap is decomposed by a measured amount (an excess) of boiling normal H_2SO_4 , then filtered and washed.		The residue (soda, ordinary salt, sodium sulphate, waterglass, borax, starch, insoluble substances, &c.) is treated with 60 ccm H_2O .	
	The filtrate — glycerine and alkali combined with fatty acid is titrated back with normal soda solution		The filtrate is divided into 4 parts.	
	The remainder containing fatty acids and resin is dried at 110° and weighed. An aliquot part is dissolved in 20 ccm strong alcohol, and after the addition of phenolphthalein saponified with a slight excess of boiling soda. On cooling it is made up with ether to 110 ccm treated with finely powdered silver nitrate, shaken 10 minutes, and allowed to settle.		The soda is titrated with normal sulphuric acid and calculated as Na_2CO_3 .	In the remainder the starch is estimated by inverting with acid, and determining the sugar with FEHLING's solution. After the amount of starch has been calculated from this the difference gives the amount of insoluble substance. If only starch is present beside mineral components it may be weighed, then reduced to ash, and weighed again.
	The amount of H_2SO_4 found by the difference is equivalent to the fatty acid, and is calculated as KOH or NaOH.			
The titrated filtrate is evaporated to dryness on the water-bath and extracted with absolute alcohol. The solution is evaporated in a small weighed dish, and the remainder weighed as glycerine.				
The precipitate contains the silver salts of stearic, palmitic, and oleic acid.				
The solution containing the salt of the resinous acid is half filtered, decomposed with 20 ccm hydrochloric acid (1:2), and an aliquot part is dried — after the evaporation of the solvent — in a weighed basin at 100° and then weighed. (For every 10 ccm solution 0.00235 g of dissolved oleic acid must be subtracted). By subtracting the amount of resin found from the amount found above of resin and fatty acids the weight of the latter can be found.		The common salt is treated with silver nitrate.		
		Barium chloride is added, the $BaSO_4$ weighed, and from this Na_2SO_4 is ascertained.		
		It is decomposed with HCl, the silica precipitated and weighed, and the sodium determined. In the filtrate the presence of borax may be shown by dipping in a slip of turmeric paper and then drying at a gentle heat.		

palm oil and resin, brown with caramel, while other colours are produced with the above mentioned substances. Soaps obtained by cold methods are dyed and mottled with water-soluble coal-tar colours. The latter have recently been much used for boiled soaps.

Soap cresol, see "CRESOL SOAP".

Soap powder (*Sapo pulveratus*). There are soap powders produced by grinding neutral soaps for toilet purposes, and also medical soap powders — specially pure soaps —, and soap powders used in laundries. The last are made from soap residues or crude alkaline soap with soda.

Soapstone (Saponite, steatite). A hydrated magnesium silicate, a species of talc (q. v.); it is amorphous, occurs in nut-, kidney- and ball-shaped clusters. Colour: grey, yellowish or greenish white. Soapstone has a fatty or soapy touch, may be cut and turned, becomes white when heated and is very hard at high temperatures.

Soda, caustic. This is a product consisting chiefly of sodium hydroxide (caustic soda) NaOH , though as a rule containing more or less Na_2CO_3 . When caustic soda is to be obtained directly from crude soda the melt (see "SODIUM CARBONATE") is treated with more carbon at the beginning and washed with slightly warmer water (50°C) then usual and the less concentrated solutions tapped off. The simplest way of preparing caustic soda is from the red liquor obtained by washing crude soda (q. v.); these lyes contain considerable quantities of NaOH , so that they may be evaporated down directly and the separated salts removed so that only the Na_2S in the remaining caustic soda lye need be destroyed.

NaOH from fully prepared soda is produced by the use of $\text{Ca}(\text{OH})_2$; the soda lyes used, must, however, not be stronger than 11—13° Bé, as otherwise the reaction will be incomplete. The soda lyes are treated with the lime at boiling point, the necessary motion being effected either by stirrers or air currents (KÖRTING's injectors); in the latter case the greater part of the Na_2S is oxidized. The lime, placed in a sieve, is slaked in the solution itself. After the reaction the clear lye is removed, filtered through a suction filter and evaporated in pans (or in steam boilers). When a concentration of 38° Bé is reached the lye is left to stand a while and then decanted from the separated salts (chiefly Na_2SO_4 and Na_2CO_3). It then passes through clarifying vessels again and into the actual melting boilers where it is evaporated until it has a boiling point of 160° when the separated salts and mud are removed and boiling continued to a B. P. of 360° . Then the vessel is covered and the Na_2S still present, oxidized by gradually adding NaNO_3 in small quantities or injecting air for several hours.

According to another (patented) method caustic soda is obtained by heating a mixture of pure soda with iron oxide in revolving ovens at a low red heat: CO_2 escapes while sodium ferride remains. When washed with hot H_2O (80 — 90°C) the sodium ferride decomposes, NaOH dissolves and Fe_2O_3 remains behind; the latter is dried and re-introduced into the process.

The vessels used in evaporating caustic soda lyes are strongly attacked. This disadvantage is obviated by French Pat. 352076, which removes the water from the lyes at 180°C under reduced pressure; the substance becomes thick and solid and falls to a powder when stirred in a suitable manner.

Germ. Pat. 140605 dealing with the purification of NaCl solutions states that the conversion of sodium sulphate into NaOH and CaSO_4 by means of quick lime may be carried out on a commercially profitable scale when the raw materials act on each other in a solution of common salt. It is not impossible that this process for the preparation of caustic soda will become important.

The electrolytical production of NaOH from sodium chloride has attained great importance. See "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

Caustic soda is also said to be obtained by the electrolysis of aqueous solutions of sodium sulphate. For instance according to French Pat. 332510 Na_2SO_4 solutions rendered caustic by the addition of lime are electrolyzed.

Test. Great care must be taken in obtaining the sample; a crust (due to the absorption of H_2O and CO_2) may be present and must be scraped off before weighing.

The examination as a rule only tests the total alkalinity, the caustic soda, and under certain circumstances, water, sodium chloride and sulphate. The total is determined with standard hydrochloric acid and methyl orange in the cold, as in the test for soda; the results are also calculated like those of soda. See the table (*Sodium carbonate*), under SODIUM COMPOUNDS. The determination of NaOH is done in the way mentioned, i. e. by titration with HCl and methyl orange (or phenolphthaleine) after adding excess of BaCl_2 . The water cannot be determined by direct heating in porcelain crucibles as losses are unavoidable. According to LUNGE 5 g caustic soda are heated for several hours to 150° on a sand-bath in a small completely dry ERLLENMEYER flask (height 14–15 cm; capacity about $\frac{1}{4}$ l). The flask with a funnel placed in the neck is weighed previously; the substance should cover the bottom of the flask as a thin layer. Finally the flask and funnel are allowed to cool on a marble slab and re-weighed.

The other determinations are perfectly analogous to those used for examining sodium carbonate (q. v.).

The S. G. of solutions of pure caustic soda are given in the following table:

S. G.	De- grees Bé	% Na_2O	% NaOH	S. G.	De- grees Bé	% Na_2O	% NaOH
1.007	1	0.47	0.61	1.220	26	15.18	19.58
1.014	2	0.93	1.20	1.231	27	15.96	20.59
1.022	3	1.55	2.00	1.241	28	16.76	21.42
1.029	4	2.10	2.71	1.252	29	17.55	22.64
1.036	5	2.60	3.35	1.263	30	18.35	23.67
1.045	6	3.10	4.00	1.274	31	19.23	24.81
1.052	7	3.60	4.64	1.285	32	20.00	25.80
1.060	8	4.10	5.29	1.297	33	20.80	26.83
1.067	9	4.55	5.87	1.308	34	21.55	27.80
1.075	10	5.08	6.55	1.320	35	22.35	28.83
1.083	11	5.67	7.31	1.332	36	23.20	29.93
1.091	12	6.20	8.00	1.345	37	24.20	31.22
1.100	13	6.73	8.68	1.357	38	25.17	32.47
1.108	14	7.30	9.42	1.370	39	26.12	33.69
1.116	15	7.80	10.06	1.383	40	27.10	34.96
1.125	16	8.50	10.97	1.397	41	28.10	36.25
1.134	17	9.18	11.84	1.410	42	29.05	37.47
1.142	18	9.80	12.64	1.424	43	30.08	38.80
1.152	19	10.50	13.55	1.438	44	31.00	39.99
1.162	20	11.14	14.37	1.453	45	32.10	41.41
1.171	21	11.73	15.13	1.468	46	33.20	42.83
1.180	22	12.33	15.91	1.483	47	34.40	44.38
1.190	23	13.00	16.77	1.498	48	35.70	46.15
1.200	24	13.70	17.67	1.514	49	36.90	47.60
1.210	25	14.40	18.58	1.530	50	38.00	49.02

Soda evaporating-apparatus:

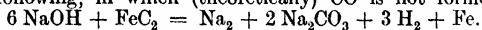
Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advt.).

Soda mercerising plants for recovering the waste caustic soda:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Sodium. Na. A. W. = 23.05. According to the old DEVILLE method 30 parts dried Na_2CO_3 , 13 parts charcoal and 5 parts chalk were mixed, ground together and then heated to white heat in cast iron pipes (protected by wider tubes of clay from direct contact with the flames. The sodium vapours are condensed in special receivers, the liquefied Na dropping into a vessel filled with an oil free from oxygen. The crude product is refined by remelting or redistillation.

By NETTO's patented method sodium was not prepared from Na_2CO_3 but from NaOH, which is reduced by C at a much lower temperature than Na_2CO_3 . The reaction is approximately: $4\text{NaOH} + 2\text{C} = \text{Na}_2\text{CO}_3 + \text{Na}_2 + 4\text{H} + \text{CO}$. In order that a red heat should be sufficient only the NaOH must be reduced and the Na_2CO_3 formed during the reaction must be tapped off. Vertical iron retorts are used (or shaft furnaces) filled $\frac{2}{3}$ full with pieces of charcoal. When the retort, covered outside by a clay coating, is heated so far that the charcoal is red, fused NaOH is allowed to drop in from a vessel above which is also heated. The Na distils and is received in oil; melted Na_2CO_3 collects at the bottom of the vessel whence it is tapped off in such a way as to prevent air entering at the same time. In CASTNER's patented method, caustic soda was also used but the reducing agent was iron carbide instead of charcoal. Iron carbide is prepared by heating Fe powder (obtained by reducing Fe_2O_3 with CO) with pitch or tar. According to the proportions of NaOH and FeC_2 , more or less Na is reduced; the most advantageous appears to be the following, in which (theoretically) CO is not formed at all:



Oval cast iron retorts taking 5 to 6 kg of soda are generally used. They are heated to low red heat. The distillation is very even taking about 1 to $1\frac{1}{2}$ hours; recharging takes barely 5 minutes.

Germ. Pat. 138368 prepares Na by heating calcium carbide to red heat with sodium fluoride or a double fluoride in a suitable vessel in the absence of air; the Na distils off. This process is said to be very cheap. According to Germ. Pat. 140737 a mixture of aluminium and sodium fluoride is heated in a distilling vessel; the Na distils over in an extremely pure state.

Germ. Pats. 159632 and 161428 deal with the preparation of alkali metals from oxides or salts by mixing them with sulphates or sulphites of the same or other metals and with sulphur, and heating the whole to a temperature above the fusion point, though lower than the point at which the metal volatilizes. Na is said to be obtained by heating Na_2CO_3 and Na_2SO_4 with S.

Apart from these last three methods the value of which is as yet not certain the first two being probably used for the preparation of potassium rather than sodium, electrolytical methods are used exclusively, those given by CASTNER and GRABAU being the most important.

GRABAU electrolyzes common salt, taking care to prevent the reunion of the elements Na and Cl separated at the two electrodes. The Na is also prevented from combining with excess of NaCl to form subchloride. For this purpose a bell-shaped cell is arranged in the vessel, the lower rim being turned outwards and upwards above the surface of the melt. This prevents the current from destroying the cell walls by passing through them. The carbon anodes are placed outside and around the bell, the iron cathode being inside. The Na separated in the cell rises to the top gradually displacing the liquid and flows through a pipe into a vessel filled with petroleum, while the Cl is removed from the anode by another tube. The vessel in which the decomposition occurs is heated by gases. Pure NaCl requires a fairly high temperature; for fusion the best mixture is 3 equivalents NaCl, 3 KCl and 2 SrCl_2 . Instead of this, others have recently come into use, particularly mixtures of the chlorides of potassium, calcium and barium which melt below a dark red heat. Fully 90 % of the current is said to be profitably used. The sodium obtained is free from Sr, Ba and Ca, and contains only 2—3.5% K.

CASTNER's electrolytical process for the electrolysis of NaOH is of special interest. The electrolyte is in a cast iron vessel with a tube at the base through which the cathode enters from below. The crucible itself has a diameter of 45 cm, the upper (cylindrical) half being 60 cm high while the union tube is 80 cm long and 8 cm thick. The cathode is surrounded by wire gauze. The object of this sieve is to allow of the current passing through while the Na set free at the cathode is confined to a limited portion of the electrolyte, and is prevented by a special device from reaching the anode where of course it would only be reoxidized. The cathode consists of copper; the anodes are arranged around the cathode and consist of an alloy of nickel and silver which oxidizes when the current passes without lowering the conductivity. As a rule 12—20 crucibles are connected in a series, requiring 110 volts and 500 to 1000 amperes. During the electrolysis the sodium and hydrogen rise inside the netting; the melted sodium floats on the surface and is taken off every now and then with iron scoops. The essential feature of this process is that the electrodes and the voltage in the crucibles are chosen in such a way that the molten alkali, when placed in the vessel is always kept at its fusion point by the current (a little above 310°C). The whole process therefore requires no additional heat. The method of the Bitterfeld works is closely related to that of CASTNER.

According to the Germ. Pat. 149558 a porous, but durable, diaphragm consisting chiefly of clay is used in the electrolysis of fused NaOH. The H_2O formed at the anodes is evaporated by an air current.

An interesting process has been worked out by LORENZ in collaboration with CLARK and SÄCHER. Its main feature is the prevention of the formation of the metallic cloud which greatly reduces the output. The anhydrous fused NaOH is electrolyzed in an iron vessel, the anode consisting of an iron sheet. A magnesite cylinder dips into the vessel and the cathode (an iron wire) passes through the lower end of this.

According to Amer. Pat. 697997 a great deal of economy is effected in electrolyzing NaOH by using a mixture of equal parts of caustic soda and sodium sulphide at a voltage so low that only the sodium sulphide is decomposed. Na appears at the cathode and no water is formed. The sulphur separating at the anode at once forms sodium sulphide again with the NaOH, so that in continuous working NaOH alone is added.

Germ. Pat. 160540 uses NaCl mixed with an alkali fluoride which makes it possible for the electrolysis to take place at a very low temperature. In this way the loss of Na is reduced to a minimum; the KF remains unchanged and can be easily recovered.

ASHCROFT's process, Germ. Pat. 158574 protects the preparation of Na by means of an alloy of Na and Pb prepared by electrolytical methods. A double cell arrangement is used, the first containing melted NaCl as electrolyte and the anodes of carbon or Pb; the cathode is of Pb. The second cell contains NaOH as electrolyte; the anode is formed of a fused alloy obtained from the first cell, the cathode being of Ni or Fe. The first cell is regularly charged with NaCl, and is lined with fireproof lining. This lining is not necessary in the second cell unless the fusion point of the electrolyte is comparatively high; the lower part of the cell may be of nickel covered with a lining which is a non-conductor of heat.

Several methods employ aqueous NaCl solutions [e. g. the chlorine-alkali process (q. v.) with the mercury electrode]. The sodium amalgam obtained is used as anode in a cell containing an easily fusible electrolyte [Engl. Pat. 17640 (1903)]. Amer. Pat. 782893 prepares Na from the amalgam by heating in an atmosphere of hydrogen.

The Engl. Pat. 19196 (1903) prepares Na from sodium aluminate by mixing with coal or tar and reducing in an electric furnace.

Na is a silver-white lustrous metal, hard and brittle at -20°C , elastic at 0° , wax-like at the ordinary temperature. M. P. 97.6° ; B. P. 742° ; S. G. (at 15°C) 0.972. As it oxidizes easily it is kept immersed in liquids containing no oxygen; petroleum (with 1 % amylalcohol) or vaseline oil.

Na is used in preparing Mg, Si, Al and several organic compounds. It is not now so extensively used since Al is prepared by electrolytically methods. It is frequently used for reactions in the form of wire made in special sodium presses.

Sodium amalgam see "MERCURY ALLOYS".

Sodium compounds.

1. SODIUM ACETATE. $\text{NaC}_2\text{H}_3\text{O}_2$. The crude salt is prepared from calcium acetate (see "CALCIUM COMPOUNDS") by treating with GLAUBER's salt and adding a little sodium carbonate solution to ensure the complete precipitation of Ca. The solution obtained is evaporated to dryness, the residues heated to 250°C to destroy organic matter, redissolved and recrystallized. According to CARL BAUER NaOH is added during the evaporation with the result that a pure product is quickly obtained. Large quantities of the acetate are also prepared from rectified acetic acid. According to Amer. Pat. 779290 calcium acetate is used, its-solutions being mixed with sodium sulphate, and barium carbonate added to precipitate the dissolved sulphates.

Sodium acetate forms colourless monoclinic columns with 3 mol. H_2O , soluble in 1 part H_2O , or 23 parts alcohol; the aqueous solution readily becomes mouldy. It is used in making acetic acid, in dyeing red and in printing materials.

2. SODIUM ALUM, see "ALUM".

3. SODIUM ALUMINATE and SODIUM ALUMINIUM CHLORIDE see "ALUMINIUM COMPOUNDS".

4. SODIUM AMIDE. NaNH_2 . Prepared according to Germ. Pat. 117623 by rapidly introducing a fine jet of ammonia into metallic Na heated above its M. P. It has recently become important in the synthesis of indigo (see "INDIGO DYESTUFFS").

5. SODIUM ARSENATE. The acid salt, NaH_2AsO_4 , is obtained by gentle but prolonged heating of 36 parts As_2O_3 with 3 parts NaNO_3 . The neutral arsenate $\text{Na}_3\text{HAsO}_4 + 12 \text{H}_2\text{O}$ is prepared by saturating the solution of the acid salt with Na_2CO_3 ; it is sometimes used in dyeing and printing to fix the mordants.

6. SODIUM BICHROMATE, see "No. 11 SODIUM CHROMATES".

7. SODIUM BICARBONATE, see No. 22 "CARBONATES".

8. SODIUM BORATE. $\text{Na}_2\text{B}_4\text{O}_7$. See "BORAX".

8 a. SODIUM BROMIDE see "BROMINE".

9. SODIUM CHLORATE. NaClO_3 . The former method of preparation from potassium chlorate and sodium silicofluoride and sodium bitartrate is no longer used. The method in which magnesium chlorate was used is also disappearing. Cl was passed into magnesia in aqueous suspension, the resulting magnesium chlorate was evaporated down to 40°Bé , converted into NaClO_3 by NaOH and Na_2CO_3 and then evaporated further to 50°Bé ; NaCl separated and NaClO_3 crystallized out in cooling. K. J. BAYER's method is rousing interest; it is mentioned in detail under potassium chlorate (No. 6 in "POTASSIUM COMPOUNDS").

NaClO_3 is now, however, mainly produced electrolytically, much like KClO_3 (q. v.). For details see under "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

10. SODIUM CHLORIDE. NaCl . For all technical details, see "SALT". The pure compound forms colourless crystals of the regular system with hexahedral fracture. 100 parts H_2O dissolve 35.5 parts at 0°C , 39.2 parts at 100°C . Insoluble in alcohol and ether; non-hygroscopic if pure. M. P. 850° .

11. SODIUM CHROMATES.

a) Neutral sodium chromate. $\text{Na}_2\text{CrO}_4 + 10 \text{H}_2\text{O}$. It is prepared by heating 6 parts powdered chrome iron ore with 3 parts calc. Na_2CO_3 and 3 parts chalk in the oxidizing flame, extracting the hot substance (45°Bé), evaporating to 52°Bé and crystallizing. For other methods see POTASSIUM CHROMATE. (No. 8 a of "POTASSIUM COMPOUNDS").

$\text{Na}_2\text{CrO}_4 + 10 \text{H}_2\text{O}$ forms yellow crystals which effloresce in air, very easily soluble in water. It is used in dyeing, and in preparing chrome colours.

b) SODIUM BICHROMATE. $\text{Na}_2\text{Cr}_2\text{O}_7$. Chrome iron stone is heated with lime, saltpetre and sodium carbonate, the whole extracted, treated with HCl when $\text{Na}_2\text{Cr}_2\text{O}_7$ and NaCl are formed; the latter is boiled out and the mother liquor concentrated.

Several other methods are in use. For instance neutral chromate is treated with H_2SO_4 . By Germ. Pat. 133736 sodium bichromate and sodium bicarbonate are produced simultaneously as follows:—A solution of Na_2CrO_4 is treated with $\text{NH}_3 + \text{CO}_2$ until 50 % of the sodium is precipitated as NaHCO_3 . The precipitate is removed and the NH_3 expelled from the solution of $(\text{NH}_4)_2\text{CrO}_4 + \text{Na}_2\text{CrO}_4$. The product is a solution of $\text{Na}_2\text{Cr}_2\text{O}_7$, which is then concentrated to the required extent. Half the CO_2 may be expelled and the remaining Na_2CO_3 be used with fresh chrome ore. For other methods see "POTASSIUM BICHROMATE" (No. 8 b of "POTASSIUM COMPOUNDS"). $\text{Na}_2\text{Cr}_2\text{O}_7$ forms orange-coloured crystals which are very efflorescent.

12. SODIUM CITRATE. Obtained from citric acid (q. v.) or calcium citrate by treatment with Na salts.

13. SODIUM CYANAMIDE Na_2CN_2 . According to Germ. Pat. 148045 by the action of carbon or matter containing carbon on an alkali amide at a temperature between 350° and 400°C , alkali cyanamide is formed as follows: $2 \text{NaNH}_2 + \text{C} = \text{Na}_2\text{CN}_2 + \text{H}_2$. (At 800° or above an alkali cyanide would be formed: $\text{NaNH}_2 + \text{C} = \text{NaCN} + \text{H}_2$. Germ. Pat. 90999). See also Germ. Pats. 124977, 126241, 148046 and 149678 under "SODIUM CYANIDE".

14. SODIUM CYANIDE. NaCN . General information on the preparation alkali cyanides will be found under potassium cyanide in the article "POTASSIUM COMPOUNDS". The number of methods published on this subject is so numerous that we cannot even enumerate them.

Three of the four methods most used in practice are discussed under potassium compounds. The fourth which appears to be becoming very important in preparing NaCN utilizes metallic sodium. According to this process, protected by Germ. Pat. 124977 and 126241 ammonia is allowed to act on a mixture of sodium, carbon and sodium cyanide at a temperature only slightly above the M. P. of the cyanide. Double the amount of NaCN introduced is obtained. The principle of the method is as follows: When sodium amide NaNH_2 acts on sodium cyanide at (about) 400°C , di-sodium cyanamide is obtained, $\text{NaNH}_2 + \text{NaCN} = \text{N}(\text{Na})_2 \cdot \text{CN} + \text{H}_2$, the di-sodium cyanamide can be converted by carbon into sodium cyanide. Both these processes can be effected in one operation, by temporarily forming the di-sodium cyanamide, i. e. treating the alkali metal, the calculated amount of carbon and the necessary quantity of NaCN in a reaction vessel and introducing NH_3 at a temp. slightly above the M. P. of the cyanide. According to supplementary patents 148046 and 199678 the intermediate formation of cyanamide is effected without the initial use of NaCN . The alkali amide of Na, NH_3 and C is changed into the stable alkalicyanamide at a temperature between 350 and 600° ($2 \text{NaNH}_2 + \text{C} = \text{Na}_2\text{CN}_2 + \text{H}_2$); when all the cyanamide is transformed, the temperature is raised so far that additional carbon produces the cyanide: $\text{Na}_2\text{CN}_2 + \text{C} = 2 \text{NaCN}$. Instead of solid carbon, liquid or gaseous carbon compounds may be introduced into the melted Na either together with the NH_3 or by a separate tube.

According to Germ. Pat. 160137 HCN is absorbed by NaOH while the latter is heated first to 200° C and then to 300°.

Other methods, especially that of FRANK and ERLWEIN, utilizing atmospheric nitrogen will be found under potassium cyanide (No. 9, "POTASSIUM COMPOUNDS"). The latter method gives di-cyanogen di-imide which forms NaCN (and NH₃) when fused with Na₂CO₃. Very similar to FRANK's method is that protected by the Amer. Pat. 787380 which allows Na₂CO₃ to act on a cyanide of the alkaline earth metals and cyanamide at a strong red heat; after extraction NaHCO₃ is added and NaCN crystallized out at a maximum temperature of 5°. The impurities remain dissolved.

Germ. Pat. 176080 deals with the preparation of alkali cyanides from the nitrides which are easily prepared. Magnesium or calcium nitride is heated with a mixture of carbon and an alkali carbonate. The mixture gets red-hot and without further heating the reaction proceeds, and cyanide is formed.

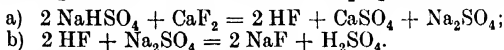
According to Germ. Pat. 180118 the yield is improved if an alkali metal be substituted for the carbonate; the Mg appears then to act as a contact substance, e. g. 23 parts Mg, 92 parts Na and 92 parts C are heated in pure N. The Na is converted almost quantitatively into NaCN: $3 \text{ Mg} + \text{N}_2 = \text{Mg}_3\text{N}_2$. $\text{Mg}_3\text{N}_2 + 2 \text{ Na} + 2 \text{ C} = 3 \text{ Mg} + 2 \text{ NaCN}$.

French. pat. 347373 protects a method of purifying cyanides by distilling them in presence of water and an ammonium salt, collecting the ammonium cyanide and decomposing with acids or bases.

Sodium cyanide is used like potassium cyanide (q. v.) and appears to be replacing it in several instances.

15. SODIUM FERROCYANIDE, see "IRON COMPOUNDS".

16. SODIUM FLUORIDE. NaF. Obtained by neutralizing hydrofluoric acid (see "FLUORINE COMPOUNDS") with Na₂CO₃ and evaporating to crystallization. According to Germ. Pat. 116848 it is prepared as follows:



Sodium bi-sulphate is allowed to act on fluor-spar at a red heat and the resulting acid treated with the sulphate solution obtained by extracting the melt.

NaF is chiefly used for etching glass, and in spirit distillation to prevent undesirable fermentation: the acid salt NaF. HF is also largely used.

17. SODIUM FORMATE. H. COONa. In GOLDSCHMIDT's method (Germ. Pat. 86419) carbon monoxide is allowed to act on caustic soda under pressure. A considerable improvement of this process is effected by French Pat. 342168; soda lye is introduced at 200° C into a vessel filled with coke and warm CO blown through. Or, Na₂CO₃ solution is mixed with coke at 220° and then treated for some time with CO.

18. SODIUM GOLD CHLORIDE, see "GOLD COMPOUNDS".

19. SODIUM HYDROXIDE, see No. 27 "SODIUM OXIDES".

20. SODIUM HYDROSULPHITE, see "HYDROSULPHITES".

21. SODIUM HYPOCHLORITE, see "BLEACHING".

22. SODIUM CARBONATE.

a) SODIUM CARBONATE. Na₂CO₃. Three processes, all starting from common salt, are used in the commercial manufacture of sodium carbonate, the LeBLANC process, the ammonia-soda process and recently also an electrolytical process.

I. LeBLANC PROCESS.

The NaCl is first converted into Na₂SO₄. The Na₂SO₄ is fused with carbon and limestone, when two reactions take place, viz.: 1. the reduction of the sulphate to sodium sulphide ($\text{Na}_2\text{SO}_4 + 2 \text{ C} = \text{Na}_2\text{S} + 2 \text{ CO}_2$) and 2. the

conversion of the sulphide to soda and insoluble calcium sulphide ($\text{Na}_2\text{S} + \text{CaCO}_3 = \text{Na}_2\text{CO}_3 + \text{CaS}$).

The sulphate should contain as little NaCl as possible and no free H_2SO_4 ; it should be light and porous and free from fused lumps. It is generally used without previous crushing or grinding. The limestone, coarsely granulated, should be very pure and soft. The carbon is usually applied in the form of a coarse dust; it should give very little ash, coke slowly and yield a high percentage of coke. The materials are mixed in different ratios in different works; for rotating ovens the usual proportions are 100 parts sulphate, 80 parts limestone and 35–40 parts carbon.

Formerly the reaction, i. e. the melting of the crude soda, was effected in reverberatory furnaces, the turning and stirring of the mass being done by hand. This stirring is necessary to avoid the formation of lumps and to ensure the complete reaction of the separate ingredients. At present hand-stirring has practically been replaced everywhere by rotating soda ovens (cylinder ovens; revolving ovens). The "revolver" is an iron cylinder lined with fire-proof stone and rotating about its axis. The heating gases (produced by common grid firing or gas firing) sweep through the middle channel of the cylinder furnace while the latter is rotating.

When the reaction is nearly complete about 6–7 % (of the contents of the cylinder) of sulphate and the same amount of lime stone powder is added; this renders the whole substance less viscous so that it is easily poured from the revolver, and causes it to rise freely so that it can be lixiviated readily.

For a few days this substance is left exposed to damp air so that the caustic lime always present is slaked, and the whole mass loosened. The loosening of the mass assists the lixiviation, which is effected in iron boxes, 4–6 being united to form a battery. The pure H_2O first enters the box containing the substance, most of it passing out through a tap at the bottom into the next, situated lower, and so forth until it enters the box containing a fresh supply of soda. When one box is exhausted it is filled again and placed in the battery, the last in the series.

The lyes have first to clear, and that in the warm state, as otherwise impure soda would crystallize. The crude lye is evaporated in pans heated by the gases escaping from the soda ovens. During the evaporation lye is repeatedly added until a thick pulp is obtained. By stirring &c. the salt is prevented from settling and burning. The crude salt is suspended to let the water drain away, and is then brought into calcining furnaces; frequently it is previously washed by steam, a process which causes the caustic soda to dissolve.

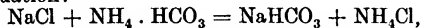
In calcining, i. e. in removing the water, fusion of the substance must be avoided; this is difficult if the soda salt contains NaOH and sodium sulphate, i. e. if these salts have not been removed by washing with steam, or if the caustic lye (red liquor) obtained during washing is also to be converted into soda. In these cases the NaOH is "carbonated" by adding sawdust during the evaporation of the soda lye; the sawdust burns to CO_2 during calcination, converting the NaOH to Na_2CO_3 , and the Na_2S to Na_2SO_4 . The same end is attained in a better way by treating the caustic lye obtained through washing by steam with CO_2 and air; or, the caustic lye is passed over coke against a current of air and CO_2 . Lime-kiln gases, or coke gases are employed as CO_2 ; the carbonated caustic lye is evaporated and calcined together with the soda from the washing. The construction of the calcining ovens varies considerably; they are usually fitted with stirrers, as otherwise frequent turning and stirring by hand are necessary.

The soda thus obtained is rarely quite white, or completely soluble in H_2O . It is refined by redissolving in H_2O , clarifying the solution, destroying organic substances by bleaching powder, evaporating to dryness and calcining as before.

Attempts have always been made to utilize the great quantities of residue from the **LEBLANC** process. The most important methods are 1. that of **SCHAFFNER** and **HELBIG**, and 2. that of **CHANCE**. Both are discussed in the article on "**SULPHUR**". The latter is combined with **CLAUS'** method, producing water and S by the combustion of H_2S with an exactly equivalent amount of O, the H_2S may also be burnt to SO_2 and worked into "**SULPHURIC ACID**" (q. v.).

II. AMMONIA-SODA PROCESS.

This process converts NaCl directly into Na_2CO_3 , i. e. not as in **LEBLANC'S** process through Na_2SO_4 or other sodium salts. The principle of the process is given by the equation:—



i. e. common salt is converted by ammonium bicarbonate into sparingly soluble sodium hydrogen carbonate, sal ammoniac remaining in solution. By heating the NaHCO_3 it is converted into the neutral carbonate. In practice a mixture of NH_3 and CO_2 instead of $\text{NH}_4 \cdot \text{HCO}_3$ is allowed to act on NaCl . The sal ammoniac solutions are distilled with lime when the NH_3 escapes and is reintroduced into the process. At the same time when the NaHCO_3 is heated half the CO_2 is again liberated and is also utilized. That is, theoretically the original amount of NH_3 should not be used up, fresh quantities of CO_2 only being necessary; in practice considerably more fresh CO_2 is necessary, and losses of NH_3 cannot be avoided.

A cold saturated solution of common salt is used, as a rule the original salt solution from salt works, as this saves the expense of first preparing salt and then redissolving it. In consequence of this circumstance — and for this circumstance only — the ammonia-soda process is economically superior to **LEBLANC'S** method; at the same time, the former is far more dependent on localities, the proximity of salt works being all-important.

NH_3 , obtained by distilling impure ammonia water (or the sal ammoniac liquors formed during the process itself) with lime is conducted into the salt solution. The NaCl solution is usually saturated with NH_3 in a column apparatus, in which the salt solution runs from above over steps and meets the NH_3 -vapours introduced from below; the heat due to absorption is counteracted by a cooler fitted around the column apparatus.

The solution saturated with NH_3 is forced into the carbonating apparatus where they encounter the carbon dioxide obtained by burning limestone¹⁾. The construction of the carbonaters varies a good deal; they are, however, generally arranged in batteries. Suitable cooling contrivances are necessary to keep the temperature below 40°C during the process, though not below 30°C .

The NaHCO_3 formed in this way, which separates on account of its being less soluble, is removed from the mother liquor by means of suction filters and carefully washed with H_2O . The bicarbonate is converted into soda by heating in reverberatory or muffle-ovens, or better still in **THELEN** pans; the escaping carbon dioxide is led back to the carbonaters.

III. ELECTROLYTICAL PRODUCTION OF SODIUM CARBONATE.

Electrolytical methods for obtaining NaOH and Na_2CO_3 from aqueous NaCl solutions are increasing in importance, as practically all difficulties experienced at first have now been overcome. By only one process can Cl , alkali hydroxides or alkali carbonates be obtained simultaneously. For this process see "**CHLORINE ALKALI PROCESS, ELECTROLYTICAL**". The Na separates at the cathode and

¹⁾ In the same way the caustic lyes required to decompose the sal ammoniac liquors are prepared.

forms NaOH (and H) with water. When the NaOH is to be used for making Na_2CO_3 , it is precipitated as NaHCO_3 by passing CO_2 into the cathode chamber, the NaHCO_3 being afterwards decomposed by heat. The preparation of Na_2CO_3 through NaOH does not, however, appear to be economical.

Until the end of the year 1870 nearly all soda was produced by LEBLANC's process, while at present 80 % is obtained by SOLVAY's process (ammonia soda process). Possibly the figures would point to a still greater success of the latter if a great amount of capital had not been invested in works of the former type. Whether the electrolytical process will, as predicted in many directions, supersede SOLVAY's process, is a matter that can hardly yet be determined.

Na_2CO_3 is sold calcined, or as CRYSTAL SODA. The latter is prepared by dissolving the purified calcined salt (free from Na_2S and NaHCO_3) in boiling water (30 to 40° Bé). A little milk of lime is added to destroy the NaOH and a little bleaching powder to decompose organic matter, and the clear solution run into crystallization vessels. Block crystals of soda are obtained according to Germ. Pat. 140826 by compressing a pulp of soda crystals under a pressure of 200 atm.

For many purposes the coarser crystalline soda is preferable to the powdery crystalline, fine soda. Germ. Pat. 104187 deals with the preparation of soda in a fine crystalline form by continuous stirring of the crystallizing soda solution during cooling by atmospheric air. The method offers various advantages, fine soda is absolutely free from mother liquor, less working power and space is necessary and finally it is ready for the market after 30 minutes treatment.

Soda crystallizes with 10 H_2O in large colourless crystals, efflorescing in the air with formation of $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$. According to LOEWEL 100 parts water dissolve at:

	0°	10°	15°	[20°	25°	30°	38°	104°
Na_2CO_3	6.97	12.06	16.20	21.71	28.50	37.24	51.67	45.47
$\text{Na}_2\text{CO}_3 + 10 \text{H}_2\text{O}$. .	21.33	40.94	63.20	92.82	149.13	237.64	1142.17	539.63

SPEC. GRAVITY OF Na_2CO_3 SOLUTIONS (LUNGE).

Spec. Gravity at 15°	Baumé De- grees	Weight percent		Spec. Gravity at 15°	Baumé De- grees	Weight percent	
		Na_2CO_3	Na_2CO_3 + 10 H_2O			Na_2CO_3	Na_2CO_3 + 10 H_2O
1.007	1	0.67	1.807	1.083	11	7.88	21.252
1.014	2	1.33	3.587	1.091	12	8.62	23.248
1.022	3	2.09	5.637	1.100	13	9.43	25.432
1.029	4	2.76	7.444	1.108	14	10.19	27.482
1.036	5	3.43	9.251	1.116	15	10.95	29.532
1.045	6	4.29	11.570	1.125	16	11.81	31.851
1.052	7	4.94	13.323	1.134	17	12.43	33.600
1.060	8	5.71	15.400	1.142	18	13.16	35.493
1.067	9	6.37	17.180	1.152	19	14.24	38.405
1.075	10	7.12	19.203				

The nomenclature of the degrees used for soda is as follows: German degrees are percentages of Na_2CO_3 , GAY-LUSSAC degrees percentages of Na_2O ,

SPEC. GRAVITY OF CONCENTRATED Na_2CO_3 SOLUTIONS AT 30° (LUNGE).

Spec. Gravity at 30°	Baumé De- grees	Weight percent		Spec. Gravity at 30°	Baumé De- grees	Weight percent	
		Na_2CO_3	Na_2CO_3 + $10 \text{ H}_2\text{O}$			Na_2CO_3	Na_2CO_3 + $10 \text{ H}_2\text{O}$
1.142	18	13.79	37.21	1.231	27	21.42	57.80
1.152	19	14.64	39.51	1.241	28	22.29	60.15
1.162	20	15.49	41.79	1.252	29	23.25	62.73
1.171	21	16.27	43.89	1.263	30	24.18	65.24
1.180	22	17.04	45.97	1.274	31	25.11	67.76
1.190	23	17.90	48.31	1.285	32	26.04	70.28
1.200	24	18.76	50.62	1.297	33	27.06	73.02
1.210	25	19.61	52.91	1.308	34	27.97	75.48
1.220	26	20.47	55.29				

French degrees (DESCROIZILLES degrees) denote the amount of H_2SO_4 which is neutralized by 100 parts soda; another standard is the equivalent percentage of NaOH . Many English works (if they do not use GAY-LUSSAC degrees) employ a system of degrees which is very uncertain and variable. The most used English degrees (Newcastle degrees) refer to percentages of Na_2O like GAY-LUSSAC, though with respect to the wrong equivalent (i. e. half molecular weight) 32 instead of 31 for Na_2O . The following table gives the various graduations in terms of each other:

The greatest quantities of soda are used in the manufacture of glass and soap; then in dyeing and bleaching works, manufacture of paper, of many Na-salts (phosphates, waterglass, borax), as a means of preventing boiler scale, in metallurgical and many other industrial processes.

For the utilization of alkali waste see the article "SULPHUR".

TEST. The amount of chemically pure Na_2CO_3 is determined from the specific gravity by LUNGE's tables. The alkalinity is determined by titration in the cold with standard hydrochloric acid, with methylorange as indicator, or with litmus at boiling point. The result of titration is expressed in degrees; (see the above table giving a comparison between the various soda degrees). When calcined soda is to be examined it must under all circumstances be heated slightly before testing. In examining pure soda the material points are the determination of the insoluble matter, the common salt, the sulphate, less frequently of the sodium sulphide, the sodium sulphite, iron, &c. The insoluble matter is determined by treating 50 g soda with warm water, stirring for some time, filtering, washing with hot H_2O and after drying, weighing on the filter. To determine the iron oxide contained in the insoluble matter, the dry filter after weighing is moistened again with H_2O and the Fe_2O_3 on the filter dissolved in warm HCl . The filtrate is precipitated with NH_3 , the residue after filtering is dissolved in dilute H_2SO_4 (1 : 4), reduced with Zn and titrated with $\text{N}/_{10}$ permanganate solution. NaCl is determined by adding HNO_3 to the soda solution until exactly neutral or faintly alkaline in reaction and then titrating with silver solution using K_2CrO_4 as indicator. Sulphate is determined by preparing a solution of soda in HCl and precipitating the hot filtrate with BaCl_2 . The amount of sodium sulphide is found by dissolving 5 g soda in 100 ccm H_2O , heating the solution to boiling, adding NH_3 and then titrating with ammoniacal silver solution until no more black Ag_2S is formed. (The ammoniacal silver solution is prepared by dissolving 13.845 g pure silver in pure HNO_3 , adding 250 ccm NH_3 solution and diluting with H_2O to 1 litre. 1 ccm of this solution of silver = 0.005 g Na_2S .) The sodium sulphite is

Gay-Lussac Degrees Na_2O	German Degrees Na_2CO_3	English Degrees Na_2O	Descroizilles Degrees H_2SO_4	Gay-Lussac Degrees Na_2O	German Degrees Na_2CO_3	English Degrees Na_2O	Descroizilles Degrees H_2SO_4	Gay-Lussac Degrees Na_2O	German Degrees Na_2CO_3	English Degrees Na_2O	Descroizilles Degrees H_2SO_4
0.5	0.85	0.51	0.79	26.5	45.31	26.85	41.88	52.5	89.76	53.19	82.98
1.0	1.71	1.01	1.58	27.0	46.17	27.35	42.67	53.0	90.61	53.70	83.77
1.5	2.56	1.52	2.37	27.5	47.02	27.86	43.46	53.5	91.47	54.20	84.56
2.0	3.42	2.03	3.16	28.0	47.88	28.36	44.25	54.0	92.32	54.71	85.35
2.5	4.27	2.54	3.95	28.5	48.73	28.87	45.04	54.5	93.18	55.22	86.14
3.0	5.13	3.04	4.74	29.0	49.59	29.38	45.83	55.0	94.03	55.72	86.93
3.5	5.98	3.55	5.53	29.5	50.44	29.89	46.62	55.5	94.89	56.23	87.72
4.0	6.84	4.05	6.32	30.0	51.29	30.39	47.42	56.0	95.74	56.74	88.52
4.5	7.69	4.56	7.11	30.5	52.14	30.90	48.21	56.5	96.60	57.24	89.31
5.0	8.55	5.06	7.90	31.0	53.00	31.41	49.00	57.0	97.45	57.75	90.10
5.5	9.40	5.57	8.69	31.5	53.85	31.91	49.79	57.5	98.31	58.26	90.89
6.0	10.26	6.08	9.48	32.0	54.71	32.42	50.58	58.0	99.16	58.76	91.68
6.5	11.11	6.59	10.27	32.5	55.56	32.92	51.37	58.5	100.02	59.27	92.47
7.0	11.97	7.09	11.06	33.0	56.42	33.43	52.16	59.0	100.87	59.77	93.26
7.5	12.82	7.60	11.85	33.5	57.27	33.94	52.95	59.5	101.73	60.28	94.05
8.0	13.68	8.10	12.64	34.0	58.13	34.44	53.74	60.0	102.58	60.79	94.84
8.5	14.53	8.61	13.43	34.5	58.98	34.95	54.53	60.5	103.44	61.30	95.63
9.0	15.39	9.12	14.22	35.0	59.84	35.46	55.32	61.0	104.30	61.80	96.42
9.5	16.24	9.63	15.01	35.5	60.69	35.96	56.11	61.5	105.15	62.31	97.21
10.0	17.10	10.13	15.81	36.0	61.55	36.47	56.90	62.0	106.10	62.82	98.00
10.5	17.95	10.64	16.60	36.5	62.40	36.98	57.69	62.5	106.86	63.32	98.79
11.0	18.81	11.14	17.39	37.0	63.26	37.48	58.48	63.0	107.72	63.83	99.58
11.5	19.66	11.65	18.18	37.5	64.11	37.99	59.27	63.5	108.57	64.33	100.37
12.0	20.52	12.17	18.97	38.0	64.97	38.50	60.06	64.0	109.43	64.84	101.16
12.5	21.37	12.68	19.76	38.5	65.82	39.00	60.85	64.5	110.28	65.35	101.95
13.0	22.23	13.17	20.55	39.0	66.68	39.51	61.64	65.0	111.14	65.85	102.74
13.5	23.08	13.68	21.34	39.5	67.53	40.02	62.43	65.5	111.99	66.36	103.53
14.0	23.94	14.18	22.13	40.0	68.39	40.52	63.22	66.0	112.85	66.87	104.32
14.5	24.79	14.69	22.92	40.5	69.24	41.03	64.01	66.5	113.70	67.37	105.11
15.0	25.65	15.19	23.71	41.0	70.10	41.54	64.81	67.0	114.56	67.88	105.90
15.5	26.50	15.70	24.50	41.5	70.95	42.04	65.60	67.5	115.41	68.39	106.69
16.0	27.36	16.21	25.29	42.0	71.81	42.55	66.39	68.0	116.27	68.89	107.48
16.5	28.21	16.73	26.08	42.5	72.66	43.06	67.18	68.5	117.12	69.40	108.27
17.0	29.07	17.22	26.87	43.0	73.52	43.57	67.97	69.0	117.98	69.91	109.06
17.5	29.92	17.73	27.66	43.5	74.37	44.07	68.76	69.5	118.83	70.41	109.85
18.0	30.78	18.23	28.45	44.0	75.23	44.58	69.55	70.0	119.69	70.92	110.64
18.5	31.63	18.74	29.24	44.5	76.08	45.08	70.34	70.5	120.53	71.43	111.43
19.0	32.49	19.25	30.02	45.0	76.94	45.59	71.13	71.0	121.39	71.93	112.23
19.5	33.34	19.76	30.82	45.5	77.80	46.10	71.92	71.5	122.24	72.44	113.02
20.0	34.20	20.26	31.61	46.0	78.66	46.60	72.71	72.0	123.10	72.95	113.81
20.5	35.05	20.77	32.40	46.5	79.51	47.11	73.50	72.5	123.95	73.45	114.60
21.0	35.91	21.27	33.19	47.0	80.37	47.62	74.29	73.0	124.81	73.96	115.39
21.5	36.76	21.78	33.98	47.5	81.22	48.12	75.08	73.5	125.66	74.47	116.18
22.0	37.62	22.29	34.77	48.0	82.07	48.63	75.87	74.0	126.52	74.97	116.97
22.5	38.47	22.80	35.56	48.5	82.93	49.14	76.66	74.5	127.37	75.48	117.76
23.0	39.33	23.30	36.35	49.0	83.78	49.64	77.45	75.0	128.23	75.99	118.55
23.5	40.18	23.81	37.14	49.5	84.64	50.15	78.24	75.5	129.08	76.49	119.34
24.0	41.04	24.31	37.93	50.0	85.48	50.66	79.03	76.0	129.94	77.00	120.13
24.5	41.89	24.82	38.72	50.5	86.34	51.16	79.82	76.5	130.79	77.51	120.92
25.0	42.75	25.33	39.51	51.0	87.19	51.67	80.61	77.0	131.65	78.01	121.71
25.5	43.60	25.83	40.30	51.5	88.05	52.18	81.40	77.5	132.50	78.52	122.50
26.0	44.46	26.34	41.09	52.0	88.90	52.68	82.19				

found in the filtrate from this determination by acidifying 50 ccm of the filtrate with acetic acid and titrating with $N/10$ iodine solution after adding starch solution; 1 ccm of the $N/10$ iodine solution = 0.0063 g Na_2SO_3 .

When crude soda is to be examined 50 g of the powdered substance are stirred into 450 ccm boiled, CO_2 -free water at 45°C , made up to 500 ccm, left to settle and filtered. By titration of 10 ccm of this solution with standard hydrochloric acid and methylorange the total alkalinity (Na_2CO_3 , NaOH and Na_2S) is found. $\text{NaOH} + \text{Na}_2\text{S}$ are determined by adding 20 ccm soda solution to 10 ccm BaCl_2 -solution (1 : 10) in a 100 ccm flask, which is then filled with boiling water, shaken, and closed. After settling 50 ccm of the solution are pipetted out and titrated with standard hydrochloric acid and methylorange. The result is the sum of NaOH and Na_2S . To determine the Na_2S , 20 ccm soda solution are diluted with H_2O to 200 ccm, and titrated with $N/10$ iodine solution after adding starch solution and acidifying with acetic acid. 1 ccm $N/10$ iodine solution = 0.0039 g Na_2S .

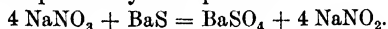
b) **SODIUM BICARBONATE.** NaHCO_3 . The NaHCO_3 formed as an intermediate product in the ammonia soda process (see "SODIUM CARBONATE") is not used as such as it contains NH_3 . Sodium bicarbonate is made from crystal soda, or, nowadays, from the purer product obtained by the ammonia soda process, by allowing steam and CO_2 to act on it at 80°C ; the reaction is completed with dry CO_2 . Sodium bichromate may also be utilized (Germ. Pat. 133736, see 11 b). The bicarbonate forms colourless crystals, mostly in crusts. They gradually become cloudy in moist air, and when heated are converted into the neutral carbonate with loss of CO_2 . 100 parts H_2O will dissolve 6.9 parts at 0° , 9.6 parts at 20° , and 16.4 parts at 60° . It is used in stripping silk, wool washing, &c. Also in medicine and for the manufacture of evervescent beverages.

TEST. All qualitative methods for detecting the presence of carbonate in bicarbonate are unreliable. Quantitatively monocarbonate is estimated by determining the carbondioxide, or by using the volumetric method with barium chloride given under "ALKALIMETRY".

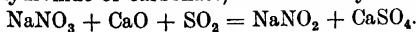
23. **SODIUM MOLYBDATE.** Obtained by dissolving molybdenum trioxide, MoO_3 in soda lye. Beside the usual salt Na_2MoO_4 there are various polymolybdates.

24. **SODIUM NITRATE.** See "CHILI-SALTPETRE".

25. **SODIUM NITRITE.** NaNO_2 . Frequently called nitrite; it may be prepared by placing dry sodium nitrate in a red hot iron crucible. It is better to use a mixture of NaNO_3 and barium sulphide, rather than the pure NaNO_3 ; the reaction is expressed by the equation:—



After cooling, the melted substance is extracted with H_2O and the solution evaporated to 40 – 45°Bé when NaNO_2 crystallizes. Germ. Pat. 59228 replaces the expensive BaS by a mixture of ground litharge and lime. Another method is used almost exclusively on a large scale. Soft lead is melted with Chili saltpetre. Many other methods have been proposed. According to Germ. Pat. 117928 sulphur dioxide — as free as possible from air — is passed over a mixture of sodium nitrate and the oxide of an alkaline earth (or instead of the latter the hydroxide or carbonate) heated nearly to fusion.



On a large scale the necessary intimate mixing of lime and Chili saltpetre is carried out by slaking the lime with concentrated saltpetre solution. The yield is said to be almost theoretical, and the separation of the insoluble gypsum to be very easy. — Germ. Pat. 138029 reduces saltpetre with sulphites. NaNO_3 is melted in presence of NaOH and anhydrous sulphite is allowed to act on the melt at 320° to 420°C with thorough stirring; the nitrite formed is extracted with nitrite mother liquor and obtained by crystallization. When

overheating is carefully avoided the yield is said to be all but theoretical. — According to Germ. Pat. 168272 NH_3 mixed with air or O is passed over metallic oxides heated to $650\text{--}750^\circ\text{C}$ (Fe_2O_3 or CuO ; ground and roasted pyrites are recommended) the nitrous acid anhydride formed is then allowed to act on a solution of NaOH or Na_2CO_3 . Germ. Pat. 160671 melts NaNO_3 with lime and graphite, extracts the NaNO_2 while the remainder is used again. French Pat. 350619 applies gas mixtures containing oxides of nitrogen (obtained, e.g. by electric discharges in air). These gases are passed straight into absorption vessels containing NaOH , where, according to the patentees, nitrite results without the formation of nitrate by oxidation.

Pure nitrite is generally sold in sticks.

26. SODIUM OXALATE. $\text{Na}_2\text{C}_2\text{O}_4$. Formerly it was obtained by neutralizing a solution of Na_2CO_3 with oxalic acid. By then adding as much oxalic acid as is required for neutralization sodium binoxalate is obtained, NaHC_2O_4 .

At present it is prepared exclusively by GOLDSCHMIDT's process from the salts of formic acid; details on this method and its improvements will be found under potassium oxalate (No. 23 a of "POTASSIUM COMPOUNDS").

27. SODIUM OXIDES.

a) SODIUM OXIDE. Na_2O . Until a short time ago it was not certain that sodium and potassium were capable of forming normal anhydrous oxides. At present, however, the preparation is possible (Germ. Pat. 147933). The respective peroxides are allowed to act directly on the metals. The reaction is very violent, setting in as soon as the substances come in contact in the presence of air. It is better to start it by means of a hot metal rod which causes the mixture to become red hot. E. g. Na_2O_2 is prepared as follows: 39 kg Na_2O_2 + 23 kg Na is ground fine, forming a dark grey powder. After the reaction mentioned a firm white substance of almost pure Na_2O remains. An alteration of this process is given by Germ. Pat. 148784; Na_2O_2 is heated with sodium and a small quantity of NaOH to a temperature above 400°C (towards the end of the process the heating is carried out *in vacuo*). Finally mention should be made of Germ. Pat. 142467. By calcining NaNO_3 with Na, not the peroxide, as was formerly believed, but Na_2O is obtained: $\text{NaNO}_3 + 5\text{Na} = 3\text{Na}_2\text{O} + \text{N}$. A saving of metallic Na is effected by the use of nitrite: $\text{NaNO}_2 + 3\text{Na} = 2\text{NaO} + \text{N}$. Na is melted in an iron stirring vessel, fused anhydrous NaNO_3 or NaNO_2 being gradually added. The vessel must be kept well closed to prevent combustion. According to the supplement to Germ. Pat. 144243 Na acts on nitrates and nitrites of the alkaline earths with formation of Na_2O ; the resulting oxides of the alkaline earths metals are obtained in the reaction product: $10\text{Na} + \text{Ba}(\text{NO}_3)_2 = 5\text{Na}_2\text{O} + \text{BaO} + \text{N}_2$ or, when nitrite is employed: $6\text{Na} + \text{Ba}(\text{NO}_2)_2 = 3\text{Na}_2\text{O} + \text{BaO} + \text{N}_2$. When nitrates are used the reaction is more violent, so that NaOH is recommended as a diluting agent. — See also potassium oxide (No. 24 a in the article on "POTASSIUM COMPOUNDS").

b) SODIUM HYDROXIDE. NaOH . For technical details see "SODA, CAUSTIC", "CHLORINE ALKALI PROCESS, ELECTROLYTICAL". Commercial caustic soda is a stone-like white substance; pure NaOH is translucent and crystalline; it deliquesces in air, absorbs CO_2 rapidly and acts as a powerful caustic.

Mention should be made of KÜSTER's process of preparing pure NaOH for use in laboratories (Zeitschr. f. anorg. Chem. 1904, 474, and Chem.-Ztg., Repert. 1904, 318).

c) SODIUM PEROXIDE. Na_2O_2 . According to Germ. Pat. 67094 it is prepared by heating sodium to 300° in aluminium vessels and passing dry air (free from carbon dioxide) over it. By the Amer. Pat. 739375 sodium is melted and exposed to excess of some oxidizing gas, e. g. air. It forms a white substance which readily dissolves in H_2O with evolution of oxygen. It is used instead

of hydrogen peroxide (q. v.) for bleaching purposes. 7.25 kg Na_2O_2 are equivalent to about 100 kg H_2O_2 of 10–12 vol. %.

A hydrate of Na_2O_2 is prepared according to French Pat. 320321 by mixing Na_2O_2 with 6–8 times its weight of crushed ice; the temperature sinks considerably and small white crystals of $\text{Na}_2\text{O}_2(\text{H}_2\text{O})_8$ are formed which are washed with alcohol and dried.

28. **SODIUM PERBORATE** (perborax). If a mixture of 248 g boric acid and 78 g sodium peroxide is gradually stirred into 2 litres of cold water the sodium perborate settles as a snow-white crystalline powder $\text{Na}_2\text{B}_4\text{O}_8 + 10 \text{H}_2\text{O}$. If at the beginning 50 % of the soda is neutralized by a mineral acid the product is the metaperborate $\text{NaBO}_3 + 4 \text{H}_2\text{O}$, white stable crystals.

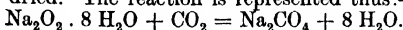
This process due to JAUBERT is protected by the French Pat. 336062. The small crystals are separated by cooling, washed with alcohol and dried at 50–60° C. A supplementary patent allows boric acid to act simultaneously with H_2SO_4 on Na_2O_2 . Engl. Pat. 22004 (1904) protects the preparation of sodium perborate from boric acid and Na_2O_2 (in molecular proportions) with the addition of a suitable acid in the cold. — Sodium perborate may also be prepared from borax and hydrogen peroxide in presence of NaOH . According to JAUBERT sodium perborate is very suitable for preparing very pure H_2O_2 , the mere solution of perborate in cold H_2O being in every respect similar to free hydrogen peroxide. When 170 g sodium perborate and 60 g citric acid are dissolved in 1 litre H_2O the result is a neutral 10 vol. % solution which in its antiseptic action is at least as strong as that of usual H_2O_2 . It is, consequently used medicinally with great advantage in the treatment of wounds (usually in the form of powder). Above 40° the solutions decompose with evolution of oxygen. The solubility of the salt is 25.5–37.8 g per litre of water at 15–32° C; by adding acids more concentrated solutions may be prepared.

Perborate of sodium "brand Erika IV":

Chemische Werke Kirchhoff & Neirath G. m. b. H., Berlin N. 24.

29. **SODIUM PERCHLORATE**. NaClO_4 . The preparation is similar to that of potassium perchlorate; see "POTASSIUM COMPOUNDS" (No. 25), "PERCHLORATES" and "CHLORINE-ALKALI PROCESS, ELECTROLYTICAL".

30. **SODIUM PERCARBONATE**. According to TANATAR sodium percarbonate, $\text{Na}_2\text{CO}_3 + 1\frac{1}{2} \text{H}_2\text{O}_2$, is obtained from sodium carbonate and hydrogen peroxide. By Germ. Pat. 145746 the same salt is obtained in the solid state by mixing liquid or solid carbon dioxide with the dry crystalline hydrate of sodium peroxide, the CO_2 being present in excess. The result is a paste-like substance which has to be separated from the small amount of water formed during the reaction and dried. The reaction is represented thus:—



31. **SODIUM PERMANGANATE**. NaMnO_4 . Prepared either like potassium permanganate (see No. 27 "POTASSIUM COMPOUNDS") or by heating manganese oxides (obtained in the regeneration of MnO_2 in the production of chlorine) with NaOH in air to 400° C. It forms a substance easily soluble in H_2O which crystallizes with difficulty; used occasionally instead of KMnO_4 as a bleaching agent and disinfectant.

32. **SODIUM PEROXIDE**, see No. 27 c.

33. **SODIUM PERSULPHATE**. $\text{Na}_2\text{S}_2\text{O}_8$. It is obtained by the electrolysis of Na_2SO_4 with H_2SO_4 and is used commercially as an oxidizing agent.

34. **SODIUM PHOSPHATE**. Na_2HPO_4 . On a large scale bone ash or natural phosphorites are used for its preparation; 10 parts basic calcium phosphate are digested with 50 parts H_2O and 9 parts concentrated H_2SO_4 for several days. The resulting pulp is filtered through linen and the liquid containing free H_3PO_4 and monocalcium phosphate $\text{CaH}_4(\text{PO}_4)_2$ evaporated down to

20 parts, and allowed to stand to precipitate dissolved calcium sulphate. The solution is diluted, the whole of the Ca precipitated by neutralizing with Na_2CO_3 -solution, filtered, evaporated in iron boilers and allowed to crystallize. According to other methods calcium phosphate solutions are decomposed with Na_2SO_4 and the resulting acid salt Na_2HPO_4 converted into neutral phosphate Na_2HPO_4 , or into basic phosphate Na_2PO_4 by adding Na_2CO_3 . Phosphorites are dissolved in HCl and the solutions then treated with Na_2SO_4 . The neutral salt $\text{Na}_2\text{HPO}_4 + 12 \text{H}_2\text{O}$ forms large, colourless crystals having a cooling, saline taste, readily deliquescent, slightly alkaline reaction, soluble in 4 parts cold, or 2 parts hot H_2O . The crystals easily melt when heated, forming sodium pyrophosphate $\text{Na}_4\text{P}_2\text{O}_7$. Sodium phosphate is used as a glaze, also in tin-plating, soldering and welding, dyeing, and finally in medicine. By dissolving 5 parts Na_2HPO_4 and 2 parts $(\text{NH}_4)_2\text{HPO}_4$ in hot water and cooling so-called microcosmic salt is formed, i. e. acid ammonium sodium phosphate $\text{Na}(\text{NH}_4)\text{HPO}_4 + 4 \text{H}_2\text{O}$; it forms large transparent, monoclinic crystals which easily melt leaving behind sodium metaphosphate NaPO_3 . This is the reason the salt is used in blowpipe experiments and in making beads of microcosmic salt.

35. SODIUM PLUMBATE, see No. 19 "LEAD COMPOUNDS".

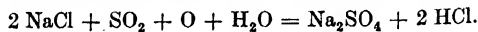
36. SODIUM SULPHOCYANIDE. NaCNS . The preparation is very similar to that of the potassium salt (see No. 30 "POTASSIUM COMPOUNDS"). It is used as a mordant in dyeing and printing.

37. SODIUM SILICATE, see "WATERGLASS".

38. SODIUM STANNATE. $\text{Na}_2\text{SnO}_3 + 3 \text{H}_2\text{O}$. Obtained from tin stone and NaOH or by heating Sn with NaOH and NaNO_3 ; also by boiling Sn with PbO and soda lye, when the Sn dissolves and Pb separates. The commercial substance is granular generally containing a considerable amount of impurities, so that hardly more than 40—44 % SnO_2 instead of the theoretical 56.4 % is present.

39. SODIUM SULPHATES. Na_2SO_4 . The greatest quantities are obtained by heating NaCl with H_2SO_4 . The change takes place in two phases; the first product is sodium bisulphate NaHSO_4 ; on further heating Na_2SO_4 is formed. The first part of the process is carried out in pans, the second by strongly heating in furnaces. The sodium chloride used (common salt, or rock salt) should be very pure and not too finely ground; the H_2SO_4 is as a rule of 59—60° Bé. When the first phase is ended the pans are emptied into the ovens. Mechanical furnaces effecting the stirring and emptying from the pans appear to be satisfactory; in any case they have come into use. (See also "HYDROCHLORIC ACID".)

Another method of preparing sodium sulphate from common salt is by the action of sulphur dioxide and moist oxygen:—The NaCl is moistened, compressed into solid cakes, dried and exposed to the action of the gases in suitable decomposing vessels. The gases used are the gases from pyrites burners (see "SULPHURIC ACID") as these contain the necessary O besides the SO_2 . Before entering the decomposition vessels the gases are mixed with steam. The reaction taking place is given by the following equation:



According to Germ. Pat. 136998 (OEHLER's method modified by TH. MEYER) Na_2SO_4 and concentrated HCl-gas are prepared by heating (requisite temperature = 400° C) an intimate mixture of well-powdered NaCl + NaHSO_4 in proper proportions in a closed vessel fitted with a gas outlet tube, avoiding all mechanical stirring. The bisulphate from the manufacture of HNO_3 can be utilized in this way. It appears very doubtful whether this process will become of practical use.

According to Engl. Pat. 6898 (1904) neutral sodium sulphate and SO_2 are prepared from bisulphate by heating the latter in a cast iron retort, where it is well mixed by stirrers, with about 12 % of its weight of sawdust and 2 % of coke dust: SO_2 escapes and Na_2SO_4 remains.

Most of the sodium sulphate is used in the crude state for the preparation of sodium carbonate (q. v.). If however it is to be purified a boiling saturated aqueous solution is prepared, neutralized with milk of lime and a solution of bleaching powder added while stirring and keeping at boiling point, until all Fe is precipitated. The precipitate settles very quickly, and the clear solution is tapped off and allowed to crystallize. If the solution cools without disturbance large crystals are formed, while small ones may be produced by stirring the liquid. Frequently also the clear solution free from iron is evaporated, the salt on settling is taken out and completely calcined by heating in ovens.

$\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$ is known as GLAUBER'S salt. It occurs naturally in many mineral springs, on the shores of lakes, &c. It is as a rule obtained from the residues formed in working carnallite (see "ABRAUM SALTS"). This residue contains about 45–55 % NaCl and 25–30 % MgSO_4 ; the substance is left exposed to the air for some time, when a solution of about 31–33° Bé (at 33°) is made, placed in shallow crystallizing vessels and allowed to stand over night (winter temperature). The reaction $\text{MgSO}_4 + 2 \text{NaCl} = \text{Na}_2\text{SO}_4 + \text{MgCl}_2$ takes place and the GLAUBER'S salt separates; it is freed from the mother liquor by recrystallization and is dried at about 30° C. When calcined GLAUBER'S salt for glass works is required a clear solution of the crude salt is evaporated and the above process applied.

The following table by LOEWEL gives the solubility of Na_2SO_4 in 100 parts H_2O .

Temperature	Anhydrous salt		Crystals with $10\text{H}_2\text{O}$		Crystals with $7 \text{H}_2\text{O}$		
	Na_2SO_4	$\text{Na}_2\text{SO}_4 + 10 \text{H}_2\text{O}$	Na_2SO_4	$\text{Na}_2\text{SO}_4 + 10 \text{H}_2\text{O}$	% Na_2SO_4	$\text{Na}_2\text{SO}_4 + 7 \text{H}_2\text{O}$	$\text{Na}_2\text{SO}_4 + 10 \text{H}_2\text{O}$
0°	—	—	5.02	12.16	19.62	44.84	59.23
10	—	—	9.00	23.04	30.49	78.90	112.73
15	—	—	13.20	35.96	37.43	105.79	161.57
18	53.25	371.97	16.80	48.41	41.63	124.59	200.00
20	52.76	361.51	19.40	58.35	44.73	140.01	234.40
25	51.53	337.16	28.00	98.48	52.94	188.46	365.28
26	51.31	333.06	30.00	109.81	54.97	202.61	411.45
30	50.37	316.19	40.00	184.09			
33	49.71	305.06	50.76	323.13			
34	49.53	302.07	55.00	412.22			
40.15	48.78	290.00					
45.04	47.81	275.34					
50.40	46.82	261.36					
59.79	45.42	242.89					
70.61	44.35	229.87					
84.42	42.96	213.98					
103.17	42.65	210.67					

Concerning this table we should remark that $\text{Na}_2\text{SO}_4 + 10 \text{H}_2\text{O}$ cannot exist above 34° C. Only the anhydrous salt can then be in the solution, its solubility decreasing continuously from 18°–103.17°. Below 18° the dissolved anhydrous salt crystallizes with $7 \text{H}_2\text{O}$ when excluded from the air, and with $10 \text{H}_2\text{O}$ when air is admitted. The solubility of $\text{Na}_2\text{SO}_4 + 7 \text{H}_2\text{O}$ rises from 0–26°; above this temperature it is changed into anhydrous salt.

The chief use of Na_2SO_4 is in the manufacture of sodium carbonate; considerable quantities, however, are also used in the manufacture of glass and

ultramarine, coal-tar-colour works, and in dyeing. The crystallized salt is used medicinally and for the preparation of freezing mixtures.

TEST. Free acid is determined by titration with standard sodium hydroxide and methylorange (in the cold); sodium chloride in accurately neutralized solution, by titration with silver solution, using K_2CrO_4 as indicator; Fe is determined by dissolving 10 g of the sulphate in H_2O , reducing the iron salts with $Zn + H_2SO_4$ and titrating with $KMnO_4$. The determination of the insoluble salts of Ca, Mg and Al is carried out as usual.

To determine the amount of sodium sulphate 1 g sulphate (if necessary with the addition of a little HCl) is dissolved, salammiac and ammonia added, Ca and Fe precipitated with ammonium oxalate solution and the filtrate evaporated to dryness after the addition of a few drops of H_2SO_4 and weighed, after heating at first alone and then with a small piece of ammonium nitrate. From the weight found is subtracted 1. the NaCl previously determined, calculated as Na_2SO_4 (1 part NaCl = 1.2136 parts Na_2SO_4), and 2. the magnesium previously determined and calculated as $MgSO_4$ (1 part MgO = 2.9703 parts $MgSO_4$). The remainder is the Na_2SO_4 in 1 g.

Sulphates:

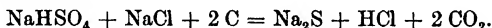
R. & J. Garroway, 58 Buchanan St., Glasgow.

Sulphate of alumina and Sewage cake:

R. & J. Garroway, 58 Buchanan St., Glasgow.

b) **SODIUM BISULPHATE.** $NaHSO_4$. Obtained by dissolving equi-molecular quantities of Na_2SO_4 and H_2SO_4 in H_2O and evaporating the solution; also by decomposing $NaNO_3$ with H_2SO_4 (see "NITRIC ACID").

40. **SODIUM SULPHIDE.** There are several sodium sulphides; monosulphide Na_2S , is obtained by the reduction of Na_2SO_4 with carbon, and according to the recent Germ. Pat. 126601 when sodium bisulphate is heated with sodium chloride and carbon:



It is usually prepared as a by-product in the manufacture of $BaSO_4$; see the article Baryta white in "BARIUM COLOURS". According to French Pat. 319187 Na_2S is obtained either by mixing Na_2SO_4 with a little more carbon than would suffice to produce the sulphide and exposing the mixture to the heat of electric furnaces (arc or resistance) with exclusion of air; or $NaHSO_4$ is used in place of Na_2SO_4 . In this case sufficient NaCl should be added to produce $Na_2SO_4 + HCl$. The vapours of HCl may in this case be collected in receivers.

Another sodium sulphide is sodium sulph-hydrate $NaSH$, produced industrially from the calcium sulphide present in alkali waste with sodium bisulphate in the cold:



the solution when boiled gives monosulphide Na_2S and H_2S . Finally there are various sodium poly-sulphides, the more important being sodium pentasulphide Na_2S_5 which is formed when the proper amount of Na is added to melted S. — Germ. Pat. 132265, treat of the preparation of sodium sulphides from gas.

41. SODIUM SULPHITES.

a) **SODIUM SULPHITE.** Na_2SO_3 . A given quantity of soda solution is divided into two equal parts. One part is saturated with SO_2 and the resulting bisulphite converted to neutral sulphite by mixing with the other part. Commercially it is obtained from $NaHSO_3$, discussed under b) by neutralizing its solution with the equivalent amount of crystal soda, evaporating to 40° B \acute{e} ,

clarifying, and crystallizing; as a rule it crystallizes with 7 H₂O. According to Germ. Pat. 138028 Na₂SO₃ is said to be obtained from ZnSO₃ by treating zinc sulphite in presence of H₂O with NaCl and possibly also with SO₂. The ZnSO₃ is obtained from roasted zinc ores by treatment with SO₂ or gases from pyrites ovens; the process may be effected in a solution of NaCl which will at the same time give a solution of ZnCl₂ and Na₂SO₃. The Na₂SO₃ may then be separated by evaporation or salting out with NaCl. It is advisable to add a sufficient excess of NaCl to the ores, so that the sulphite is retained by the ore residues and may be separated by extraction.

Na₂SO₃ is frequently used as an antichlor (q. v.), for preserving, as a mild bleaching agent, &c.

b) SODIUM BISULPHITE. NaHSO₃. On a large scale moist soda crystals are exposed to a current of SO₂ (gases from pyrites furnaces); the bisulphite formed dissolves in the water of crystallization. It is also obtained by the action of SO₂ on NaHCO₃; another way is to allow the soda solution to absorb SO₂; the solution of soda should be of 21.5° Bé to produce a bisulphite solution of 40° Bé.

42. SODIUM THIOSULPHATE. Na₂S₂O₃. For its preparation see "ANTICHLORS." The salt forms colourless crystals with 5 H₂O, readily soluble in H₂O causing considerable lowering of temperature; insoluble in alcohol. It is used as an antichlor in the manufacture of paper, bleaching of textiles, straw, wool, bones, oil, &c., &c., as a mordant in calico printing, and in preparing various chemical compounds. The aqueous solutions dissolve much iodine, so that it is used in obtaining the latter. It is also employed in photography.

43. SODIUM TUNGSTATE. Tungsten ore (usually Wolframite) is fused with Na₂CO₃ and KNO₃ in reverberatory furnaces, extracted with H₂O, the solution neutralized with HCl and concentrated by evaporation, when sodium tungstate crystallizes out. It does not correspond to the simple formula Na₂WO₄, the composition being variable; the best crystals are those of sodium paratungstate Na₁₀W₁₂O₄₁ + 28 H₂O which occurs as a by-product in the treatment of tungsten-tin ores. It is chiefly used in the preparation of other tungsten compounds; it is also employed to render textiles less inflammable.

Solanine. C₄₂H₈₇NO₁₅. An alkaloid occurring in deadly night-shade (*Solanaceae*). It is a fairly strong poison.

Solar oil (Photogen). This is the name given to various hydrocarbons obtained as by-products in the treatment of brown coal-tar (q. v.) in paraffin works (see "PARAFFIN"). The more easily volatile substances of S. G. of 0.800 to 0.820 are called photogens, while the hydrocarbons passing over at 160—195° (S. G. 0.825—0.830) are the solar oils; a sharp distinction between the two fractions is not possible. Photogen is used to refine paraffin, for carburetting coal-gas, and for removing stains, while solar oil is used for lighting.

Another kind of solar oil is obtained in the distillation of mineral oils. It occupies a position between petroleum and lubricating oils, and is used for carburetting water gas, and to dissolve the resin acid neutralized with lime (residues of petroleum manufacture). This mixture is used to heat distilling, steam, and locomotive boilers, though only where it is found locally (especially in Russia).

Soldering. A distinction is made between soft and hard solders. The simplest soft solder is pure tin (M. P. 230°), though usually for reasons of economy alloys of Sn and Pb are used. Their melting points vary between 180° and 240° according to the proportions observed in mixing; more easily melting solders are obtained by adding Cd and Bi (see "CADMIUM ALLOYS" and "BISMUTH ALLOYS").

Hard solders vary very much indeed, e. g. pure copper, or alloys of Cu with Zn (brass), also alloys of Cu with Zn and Sn (bronzes). These solders, generally called brass solders, are used in soldering copper, bronze, brass, cast iron, and wrought iron. Harder and still more resistant are German silver solders, i. e. a German silver containing much zinc (see "NICKEL ALLOYS"), it is used in soldering articles of steel, iron, and German silver. A silver solder is an alloy of 75 % Ag and 25 % Cu, frequently containing a little brass or zinc to lower the melting point; it is used, in soldering silver, copper, steel and iron. Gold solders are alloys of Au, Ag and Cu (sometimes with a little Zn), while pure gold is used to solder platinum.

Aluminium is very difficult to solder; numerous solders have been proposed for this purpose; they generally contain Al, Cu and Sn. Aluminium bronze on the other hand may be soldered easily and well by using a hard solder consisting of 52 % Cu, 46 % Zn and 2 % Sn. Recently the electric arc has been used in soldering metals of high melting point. Other metals (e. g. lead) are now usually soldered without the addition of any solder by merely fusing the seams together, using the blowpipe flame, or for platinum an oxyhydrogen flame (autogenous soldering).

If soldering is to be successful materials must be used which protect the metal surfaces from oxidation or dissolve any oxides already formed. For soft solders, hydrochloric acid, sal ammoniac, zinc chloride, oil, colophony, turpentine and chiefly an aqueous solution of soldering salt are used. The latter, ammonium zinc chloride $\text{ZnCl}_2 + 2\text{NH}_4\text{Cl}$, is prepared by dissolving one part Zn in HCl with the addition of one part NH_4Cl . For hard solders a solution of phosphoric acid in alcohol is most frequently used; slag forming and reducing substances like borax, glass powder, potassium cyanide, &c. are dusted over the parts to be joined.

The following receipts for soldering materials (according to M. HEINZE) have proved reliable:—

a) SOLDERING SOLUTION. 1. Zinc scraps are placed in hydrochloric acid until no further evolution of gas occurs. 2. This process is carried on until added zinc remains undissolved when the liquid is warmed. 3. Liquids obtained by 1. and 2. are improved by adding a little liquid ammonia from time to time until the solution has a slight smell of ammonia. 4. To solution an eighth part of glycerine is added. 5. 0.45 kg sal ammoniac, 113 g borax and 28.3 g glycerine are dissolved in 1.5 litre water. 6. 0.45 kg lactic acid, 0.45 kg glycerine and 3.6 kg water. 7. 0.56 litres phosphoric acid (1 part phosphoric acid to 8 parts water) and 0.85 litres wood spirit.

b) SOLDERING POWDERS. 1. Powdered resin. 2. Mixture of 0.9 kg resin, 56.7 g sal ammoniac, and 16.7 g dry zinc sulphate in a powdered form. 3. 0.9 kg resin, 56.7 g sal ammoniac, and 16.7 g dry borax are powdered and mixed.

c) SOLDERING PASTES. 1. Tallow with resin. 2. 0.45 kg resin and 45 kg tallow are melted and mixed with 56 g powdered sal ammoniac. 3. 2.26 kg cotton seed oil are melted with 1.81 kg tallow, 1 kg powdered resin is added, the whole melted again; 0.12 kg powdered sal-ammoniac is added and the mixture cooled while stirring. The consistency is altered by the addition of cotton seed oil.

d) SOFT SOLDER FOR LEAD, ZINC, COPPER, BRASS, &c. 2 parts Pb and 1 part Sn (225—230°).

e) SOFT SOLDER FOR LEAD, ZINC, TIN &c. 1 part Pb and 1 part Sn (200°).

f) SOFT SOLDER FOR TIN MOULDS. 1. 2 parts Sn, 1 part Pb, 1 part Bi. 2. 3 parts Sn, 2 parts Pb and 1 part Bi (125—150°).

g) SOFT SOLDER FOR ALUMINIUM BRONZE:— 4 parts Zn and 3 parts Cd. The parts to be joined are scraped; no soldering water is used.

- h) HARD SOLDER FOR IRON, COPPER, &c. 1. 5 parts Cu and 1 part Zn.
2. 2 parts Cu and 1 part Zn.
i) YELLOW HARD SOLDER FOR IRON, COPPER, BRASS, &c. 2—6 parts brass filings and 1—2 parts Zn (400—450°).
k) WHITE HARD SOLDER. 1. 20 parts brass filings, 4 parts Sn, 1 part Zn.
2. 78 parts brass filings, 15 parts Sn and 7 parts Zn (above 426° C).
l) FLUXES. For soft solders: Soldering-liquids, -powders, -pastes and colophony. For hard solders: Borax or sal ammoniac with borax.

Solubility.

SOLUBILITIES OF VARIOUS SUBSTANCES:

Solubility of salts in 100 parts H₂O.

At	0°	10°	20°	50°	100°
Aluminium sulphate, cryst.	86.85	95.8	107.35	201.4	1132.0
“ potassium sulphate, cryst.	3.9	9.5	15.1	44.1	357.5
Ammonium chloride	28.4	32.84	37.28	50.6	72.8
“ bicarbonate	11.91	16.1	21.5	—	—
“ sulphate	71.00	73.65	76.30	84.25	97.50
Barium chloride	—	33.3	35.7	43.6	57.8
“ hydroxide	1.5	2.22	3.48	11.75	—
“ nitrate	—	7.0	9.2	17.1	32.2
Boric acid (H ₃ BO ₃)	1.947	2.880	3.992	—	29.116
Calcium chloride	49.6	60	74	120	154
“ sulphate CaSO ₄ · 2 H ₂ O ...	24.1	—	26.1	26.6	22.2
Cobalt sulphate	22.4	30.5	38.4	55.2	—
Copper sulphate	—	36.95	42.31	65.83	203.22
Lead nitrate	38.8	48.3	66.7	90	139
Lithium carbonate	1.539	1.406	1.329	1.181	0.728
Magnesium sulphate	26.9	31.5	36.2	50.3	73.8
Manganese sulphate	55.4	63.8	66.3	74.8	52.9
Mercuric chloride	5.73	6.57	7.39	11.34	53.96
Nickel sulphate	30.4	34.6	39.7	52.0	—
Potassium bromide	53.42	60.8	68.3	80.5	104.2
“ chlorate	3.33	5.0	7.6	19.0	59.9
“ chloride	27.9	32.0	34.7	42.8	56.6
“ chromate	58.90	60.92	62.94	69.00	79.10
“ bichromate	4.6	7.4	12.4	35.0	94.1
“ carbonate	89.4	109	112	121	156
“ bicarbonate	19.61	23.23	26.91	37.92	—
“ iodide	127.9	136.1	144.2	168	209
“ nitrate	13.3	21.1	31.2	86	247
“ sulphate	8.46	9.7	10.9	15.8	26.2
Silver nitrate	121.9	—	227.3	496.1	940
Sodium bromide NaBr	77.5	83.0	88.4	107.7	114.9
“ bromide NaBr + 2 H ₂ O ...	78.85	85.0	92.15	115.8	—
“ chloride	35.6	35.70	35.84	36.70	40.1
“ iodide NaI	158.7	168.7	178.6	232.3	312.5
“ iodide NaI + 2 H ₂ O	158.7	170.0	179.3	228.4	—
“ carbonate Na ₂ CO ₃	6.97	12.06	21.71	—	45.47
“ carbonate Na ₂ CO ₃ + 10 H ₂ O	21.33	40.94	92.82	—	539.62
“ bicarbonate	7.02	8.88	9.84	12.72	—
“ nitrate	72.9	80.8	87.5	112	180
“ phosphate	2.5	3.9	9.3	82.5	98.8
“ sulphate Na ₂ SO ₄ + 10 H ₂ O	5.02	9.00	19.40	46.7	42.5
“ thiosulphate (anhydrous) ..	47.6	—	69.5	114	—
Zinc sulphate ZnSO ₄ + 7 H ₂ O	115.22	138.21	161.49	263.84	653.59

Solubility of various chemicals in dilute alcohol.

(Pharmaz. Zentrallhalle 1881, No. 30).

1 g substance requires alcohol of Vol. weight 0.941 at 15.5° C.

	ccm		ccm
Ammonium bromide	3.00	Potassium acetate	0.50
“ chloride	6.00	“ bicarbonate	22.00
“ carbonate	10.00	“ bromide	4.50
Benzoic acid	20.00	“ carbonate	1.00
Cinchonine sulphate	20.00	“ chloride	88.60
Codeine	4.40	“ ferrocyanide	570.00
Copper sulphate	518.00	“ iodide	1.60
Ferrous sulphate	236.00	“ nitrate	24.00
Lead acetate	8.00	Oxalic acid	8.00
Lithium citrate	25.00	Mercuric chloride	20.00
“ carbonate	1790.00	Salicylic acid	42.00
Magnesium sulphate	47.33	Silver nitrate	2.50
Milk sugar	58.00	Strychnine sulphate	60.00
Morphine acetate	50.00	Tartaric acid	1.25
“ chloride	26.00	Sodium borate	402.00
“ sulphate	40.00	“ hypophosphite	5.80
Potassium-sodium nitrate ..	29.00	“ phosphate	298.00
“ sulphate	700.00	“ salicylate	19.60
“ sulphite	460.00	“ sulphate	81.20
“ citrate	1.00	“ thiocarbonate	18.00
Quinine sulphate	150.00	“ thiosulphate	3.00
Sodium acetate	3.00	Zinc sulphate	48.00
“ carbonate	83.33	Citric acid	1.00

Solurol = nucleotinphosphoric acid $C_{30}H_{46}N_4O_{15} \cdot 2 P_2O_5$, also called Thymic acid.

A yellow amorphous powder, easily soluble in H_2O . Said to be used for gout since at 20° it has the property of keeping in solution its own weight of uric acid.

Solutol see “CRESOLS”.

Solvent naphtha. A fraction of coal-tar (q. v.) obtained in the rectification of light oil. (See also the article on “BENZENE”.) It is a liquid S. G. (at 15° C) 0.875; about 90 % should distil at 160°, while only 20 % should distil at 130° C. Solvent naphtha contains xylenes and tri-methyl benzenes; the other constituents have, on the whole, not been thoroughly investigated. The name, solvent naphtha, is due to the circumstance that this fraction in the manufacture of waterproof materials is used to dissolve caoutchouc. It is further used to purify anthracene (q. v.).

Solveol. Cresols made soluble in water by the addition of sodium cresotinate.

It is a brown, transparent, oily, neutral liquid with a faint tar-like smell, mixing with H_2O without the separation of cresol; S. G. 1.153—1.158. Used as a disinfectant.

Somatose. A food preparation made from meat by a secret method. The chief ingredients are albumose (about 78 %) and 3 % of peptone.

A yellow, almost tasteless, odourless powder, easily soluble in H_2O . Prescribed for convalescents and in cases of indigestion, chlorosis, &c.

It is also sold as LIQUID SOMATOSE, MILK SOMATOSE and IRON SOMATOSE.

Somnal. A solution of a mixture of chloralhydrate and urethane in alcohol. Used medicinally as a hypnotic.

Somnoform (NARCOFORM). A mixture of 60 parts ethyl chloride, 35 parts methyl chloride and 5 parts ethyl bromide. Said to serve as a local anaesthetic.

Soot. By the term soot is understood the impure powdered carbon separated from organic substances by incomplete combustion. Wood or pine soot is obtained from resinous wood or the refuse of resins by burning in presence of little air, and conducting the soot-laden fumes through chambers or coarse bags.

The greater part of the soot now made is prepared in specially built soot-burning apparatus from colophony, pitch, tar, tar-oils and so on. A specially fine sort of soot, lamp black or oil black is obtained by burning oils or camphor with or without a wick. Cooled metal cylinders are adjusted over the flame to catch the soot which is removed with knives or brushes.

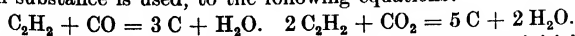
Soot is also obtained from gas-tar, which contains 30 % and more of this substance, by filtering the tar after diluting with oil. This soot is used for making crayons and carbon electrodes.

Large quantities of soot are made by the incomplete consumption of blubber, mineral oil, resin &c. In recent years this product has also been obtained in large quantities from acetylene and natural gas (America). The materials are burnt in suitable lamps or in other vessels.

Many new patents for the preparation of soot have been taken out. The following are important:— According to Germ. Pat. 132836 acetylene is heated with a halogen substitution product of a hydrocarbon, or a carbide is heated with one of the above substitution products. In this way finely divided carbon is obtained and also a halogen acid or a salt. According to Germ. Pat. 127467 and 138940 soot is obtained by distilling tar or carbonaceous materials with warm compressed air and burning the air and mixed vapours without condensation.

So far Germ. Pat. 141884 does not seem to be of practical value; according to this patent the endothermic properties of acetylene and more especially its decomposition under pressure are used in the well-known method for the production of amorphous carbon. In this method it was considered necessary to remove the air from the vessel in which the acetylene was to be decomposed, before operations were begun, but according to the new process this is no longer obligatory if there is a pressure of about 4 atm. in the vessel. An addition of gaseous exothermic hydrocarbons, or a mixture of such gases as methane, ethane or coal-gas, &c. which absorb a part of the free energy and are thereby separated into their component parts, considerably improves the quality of the amorphous carbon produced.

FRANK'S process is of much interest. According to this method a mixture of acetylene is burnt with CO or CO₂. The reaction corresponds, according to which substance is used, to the following equations:—



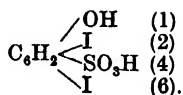
The reaction is best carried out in closed steel vessels with an initial pressure of 6 atm. and an explosion pressure of 125 atm. with electric ignition. This soot colours well, makes a good coating, is specifically heavy and is a good conductor of heat and electricity.

Germ. Pat. 157542 treats of the production of soot from naphthalene by burning the liquid substance in wick lamps. To prevent sublimation the wick funnel is kept cool by a water arrangement. The melting takes place in a water bath connected with the lamp.

Soot:

Willy Manger, Dresden, Germany.

Sozoiiodol. The sozoiiodol preparations are the salts of sozoiiodolic acid (di-iodo-p-phenolsulphonic acid)



In order to prepare it potassium p-phenolsulphonate is dissolved in HCl and treated with KI and KIO₃. The free acid is obtained from the potassium salt thus prepared by treatment with diluted H₂SO₄.

These preparations are used as substitutes for iodoform, in the form of powder, aqueous solutions or salves (mixed with talc or milk sugar). As a powder it is used as a snuff. The preparations are all free from odour.

Spanish white see "BISMUTH COLOURS".

Specific gravity.

SPECIFIC GRAVITIES OF SOLIDS.

	S. G.		S. G.
Agate	2.55—2.67	Bronze	7.4—8.60
Alabaster	2.61—2.88	Brown iron ore	3.80—4.20
Alum	1.75	Brown coal	1.20
Alum schist	2.34—2.59	Cadmium	8.66
Aluminium, chem. pure ...	2.6	Calamine	2.56—4.41
" cast	2.56	Calcium chloride	1.76
" bronze	7.7	Calcium carbonate, see	
Amber	1.06—1.11	"LIME STONE"	
Antimony	6.71	Calcium oxide, see "LIME"	
" blende	4.50—4.60	Calcespar	2.62—2.75
" sulphide	4.70—4.85	Camphor	0.99
" oxide	5.77	Carbon from poplar wood	0.12
Argillaceous schists	2.75—2.90	" fir wood ...	0.60
Arsenic	5.77	Caoutchouc	0.93
Asbestos	0.91—2.44	Chalcedony	2.66
Asphalt	1.07—1.16	Chalk	2.69
Baryta	4.00	Chromium	5.90
Barium	4.00	" oxide	5.21
" acetate	1.83	Chrysoprase	2.48
" carbonate	4.30	Cinnabar	8.12
" nitrate	2.92	Clay	1.8—2.6
" sulphate	4.20	Clay, fresh	1.67—2.9
Basalt	2.41—2.86	" dry	1.52
Bell metal	8.80	Coal	1.21—1.51
Bismuth	9.40—9.82	" trimmed,	
" oxide	8.97	" untrimmed,	
Blood stone	4.36	in small lumps	0.85—0.95
Bones	1.7—2.0	ditto in large lumps	0.95—1.05
Brass	8.2	Cobalt	8.5—9.5
Bricks	1.4—2.30	" glance	6.0—6.1
Brick work with lime		Celestine	3.95
mortar: of quarried stone	2.40	Coke	1.4
of Sand stone .	2.05—2.12	" untrimmed	0.55
of Bricks	1.47—1.59	Colophony	0.93—1.20

	S. G.		S. G.
Copal	1.04—1.06	Magnesite	3.0
Copper, cast	8.79	Magnesium	1.74
“ fused	8.94	Manganese	8.01
“ hammered	8.88	Marble	2.52—2.86
“ glance	8.70	Marl	2.30—2.70
“ pyrites	4.17	Mastic	1.04
“ acetate	1.78	Mercuric oxide	11.07
“ oxide	6.43	Mica	2.51—3.07
“ sulphate (cryst.) ..	2. —2.3	Minium	9.10
Cork	0.24	Mother of Pearl	2.76
Cream of Tartar	1.85	Moulding sand, stamped ..	1.65
Cryolite	2.69	Naphthalene	1.05
Diamond	3.65—3.44	Nickel	8.7—9.2
Dolomite	2.79	Ochre	3.5
Emery	4.0	Paraffin	0.87
Fahl ore	4.80—5.10	Phosphorus, white	1.77
Felspar	2.53—2.60	“ red	2.18
Flint	2.58—2.59	Phosphorbronze	8.9
Garnet	3.56—4.25	“ iron	6.70
German silver	8.4—8.7	“ copper	8.9
Glass, Plate	2.37—2.56	Phosphoric acid	1.56
“ Window-	2.64	Pitch, white	1.07
“ Flint-	3.30	“ blonde	6.50—6.60
“ Green-	2.81	Plaster of Paris	2.17—2.31
“ Crystal-	2.89	Platinum, hammered	20.34
Glue	1.27	“ rolled	22.07
Gold	19.36	“ wire	21.40—21.50
Granite	2.54—2.96	Porcelain	2.15—2.39
Graphite	1.70—2.33	Porphyry	5.77—5.79
Gravel, dry	1.8	Potassium	0.865
Gun Arabic	1.36—1.44	“ bromide	2.42
Gum lac	1.14	“ carbonate	2.26
Gun metal	8.44	“ chloride	1.84
Heavy spar	4.56	“ ferrocyanide ..	1.83
Hornblende	3.33—3.41	“ hydroxide	2.66
Indigo	0.77	“ iodide	3.08
Iron cast	7.21	“ nitrate	1.98
“ welded	7.79	“ sulphate	2.62
“ cast steel	7.92	Pumice stone	0.91
“ pyrites	4.60—4.88	Pyrates	4.9—5.3
“ steel, tempered	7.82	Quartz	2.65
“ steel, soft	7.83	Red lead ore	5.95
Iodine	4.95	Red copper ore	5.70—6.00
Ivory	1.83	Resin, pine	1.07
Jasper	2.31	Rock salt	2.26
Kaolin	2.21	Rubber	1.18
Lava	2.80	Ruby	3.13—3.99
Lead	11.39	Sal ammoniac	1.53
“ chloride	5.80	Sand stone	2.09—2.62
“ carbonate	6.43	Sapphire	3.13—4.83
“ oxide	9.28	Serpentine	2.68
Leather, dry	0.86	Selenium	4.30
“ grease	1.02	Silica, amorph.	2.2
Lime, quick	2.3—3.2	“ cryst.	2.6
“ slaked	1.3—1.4	Silver	10.47
“ mortar, dry	1.65—1.75	“ bromide	6.35
Limestone	2.46—2.84	“ chloride	5.13
Magnesia	3.0	“ iodide	5.61

	S. G.		S. G.
Silver nitrate	4.35	Uranium pitch blende ...	6.60
Slag (Blast furnaces)	2.5—3.2	Wax	0.96—0.98
Slate	2.67	Whalebone	1.24
Smalt	2.44	Wood, air dried:	
Soapstone	2.61	“ Ash	0.67
Sodium	0.98	“ Aspen	0.43
“ carbonate	2.47	“ Acacia	0.65—0.70
“ chloride	1.89	“ Alder	0.48
“ hydroxide	2.81	“ Beech	0.73
“ sulphate	2.25	“ Birch	0.70—0.74
Soil, clay, fresh	2.10	“ Box	0.94
“ clay, dry	1.90	“ Cedar	0.56
“ poor, dry	1.30	“ Cork	0.24
Spermaceti	0.88—0.95	“ Ebony	0.78
Stearine	0.97	“ Ebony, fresh	1.33
Strass	3.50—3.60	“ Fir	0.47
Strontianite	3.7	“ Larch	0.52
Strontium carbonate	3.62	“ Lime	0.56
“ sulphate	3.59	“ Lignum vitæ	1.26
Sugar	1.50—1.62	“ Mahogany	0.75
Sulphur, amorph.	1.93	“ Maple	0.67
“ native	2.09	“ Nut	0.66
Syenite	2.6—2.8	“ Oak	0.69
Talc	2.7	“ Pear	0.60—0.73
Tallow	0.91—0.94	“ Pernambuco	1.01
Topaz	3.50—4.01	“ Pine	0.55
Tin	7.29	“ Poplar	0.38—0.39
“ perchloride	2.25	“ Red beech	0.75—0.85
“ protochloride	2.29	“ White deal	0.56
Tin-stone	6.4—7.0	“ White deal (fresh)	0.89
Tourmaline	3.02—3.25	“ Willow	0.49
Trachyte	2.6	Zinc, cast	6.86
Tragacanth gum	1.32	“ rolled	7.12—7.20
Tripoli	1.00—1.20	“ blende	4.01
Tuff	1.3	“ chloride	2.25
Tungsten	17.60	“ spar (Calamine)	4.1—4.5
Umbra	2.2	“ sulphate (cryst.)	2.04

SPECIFIC GRAVITIES OF LIQUIDS.

	S. G.	At ° C		S. G.	At ° C
Acetic ether	0.905	17	Bromine	3.187	0
“ acid (glacial) ..	1.056	15.5	Butyric acid	0.96	15
Acetone	0.792	20	Castor oil	0.969	15
Albumen	1.041	15	Carbolic acid (crude) ..	0.95—0.965	15
Aldehyde	0.801	0	Chloroform	1.480	18
Alcohol (absolute)	0.793	15	Coal-tar	1.195	0
Amyl alcohol	0.810	20	Cocoonut oil	0.925	15
Aniline	1.035	0	Colza oil, crude	0.915	15
Aniseed, Oil of	0.996	16	“ “ refined	0.913	15
Beer	1.02—1.035	—	Cotton seed oil	0.926	15
Benzene	0.899	0	Cresote oil	1.04—1.10	15
Benzine	0.68—0.70	15	Ether (ethyl)	0.736	0
Blubber	0.918—0.925	15	Glycerine (anhydrous) ..		

	S. G.	At °C		S. G.	At °C
Hydrochloric acid (40%)	1.27	100	Petroleum, light	0.795—0.805	15
HCl)	1.192	15	Photogens	0.78—0.85	15
Lavender oil	0.877	16	Pine oil	0.85—0.86	15
Linseed oil, boiled	0.942	15	Poppy seed oil	0.924	15
Methyl alcohol	0.789	0	Polishing oil	0.74—0.75	15
Mercury	13.596	0	Rape oil, crude	0.915	15
Mineral lubricating oils	0.9—0.925	20	" " refined	0.912	15
Naphtha, Petroleum	0.758	19	Sea water	1.03	4
Neats-foot oil	0.916	15	Sulphuric acid (66° B _é)	1.842	15
Nitric acid (49.9° B _é)	1.530	15	" " fuming	1.89	15
Oleic acid	0.898	15	Sulphurous acid, liquid	1.491	20
Olive oil	0.918	15	Turpentine oil	0.873	16
Palm oil	0.905	15	Valerian, Oil of	0.965	16
Petroleum ether	0.665	15	Water (distilled)	1.000	4

Specific heat is the heat required to raise 1 kg of a substance 1° C. The unit of heat is the calorie (see "FUELS"). The specific heat depends upon the

SPECIFIC HEAT OF SOME SOLIDS AND LIQUIDS.

Substance	Sp. heat	Substance	Sp. heat
Alcohol, absolute	0.7000	Pig iron, between 0 and 200°	0.13
Antimony	0.0508	" " " 0 and 1200°	0.16
Bismuth	0.0308	Platinum	0.0324
Brass	0.0939	Phosphorus	0.1887
Bricks	0.2410-0.1890	Silver	0.0570
" fire	0.2083	Steel, soft	0.1165
Cast iron	0.1298	" hard	0.1175
Charcoal	0.2411	Sulphur, solid	0.1764
Copper	0.0951	" fused	0.2026
Glass, brittle	0.1923	Sulphuric acid	0.335
" annealed	0.1937	Tin	0.0502
Gold	0.0324	Water	1.000
Iron (wrought)	0.1138	Wood, oak	0.5700
Lead	0.0314	Zinc	0.0955
Mercury	0.0333		

SPECIFIC HEAT OF SOME GASES AND VAPOURS.

Substance	Water = 1		Air = 1 const. pressure
	at const. vol.	at const. pressure	
Alcohol vapour	0.3200	0.4510	1.8986
Atm. air	0.1686	0.2375	1.0000
Carbon monoxide	0.1758	0.2479	1.0793
Carbon dioxide	0.1535	0.2164	0.9104
Ether vapour	0.3411	0.4810	2.0235
Hydrogen	2.4123	0.4090	14.3231
Oxygen	0.1548	0.2175	0.9180
Marsh gas	—	0.5930	—
Nitrogen	0.1730	0.2438	1.0265
Steam	0.3337	0.4760	0.9794

temperature. As a rule the average specific heat for a certain temperature interval is determined.

When the specific heat is calculated not with reference to the unit of mass but to the molecular weight of the substance the value is the molecular heat. The ATOMIC HEAT of all elements, i. e. the product of the atomic weight and the specific heat is approximately constant, about 6.36.

Spectrum analysis.

Spectrum apparatus:

Hans Heole, Berlin O. 27.

Microspectrum apparatus, Mikro-Catalog M 184 P. 87. 88. Spectroscope for visible and ultraviolet light Prosp. Mess 153.

Carl Zeiss, Jena (Germany).

Spermaceti. A mixture of solid and liquid waxes found in the head of the sperm whale. The "oil" soon becomes cloudy and a wax separates (*cetaceum*). To purify it the wax is strongly compressed and washed with caustic potash solution. It is a colourless, tasteless, odourless friable mass with lustre like that of mother of pearl. S. G. (at 15°) 0.942—0.960; M. P. 43.5—49°. Solidifying point 43.4—48°; saponification number 108—128. It is used for the preparation of expensive candles and transparent soaps, for finishing and in the preparation of ointments, pomades and drugs. It consists mainly of the acetyl ester of palmitic acid and is very difficult to saponify.

Spermaceti oil is a clear yellow thin liquid, S. G. (at 15°) 0.875—0.884; saponification number 132; iodine number 84. 40 % is an unsaponifiable solid soluble in alcohol. The oil does not become thick on standing and is valued as a lubricating oil (spindle oil).

Spike oil see "LAVENDER, OIL OF".

Spinning oil see "OIL".

Spirits see "ALCOHOL".

Spirit varnishes see "VARNISHES".

Spirit soap. General information will be found under "HARD SPIRITS". Ointment-like spirit soaps for toilet purposes &c. are obtained according to Germ. Pat. 134406 by dissolving about 25—35 % soap chips in 80—95 % alcohol. Germ. Pat. 149793 has for its object the preparation of a spirit soap, made of a soda soap obtained from cocoa nut oil, containing a high percentage of alcohol. It melts only with difficulty.

Spodium. Spodium (black spodium) is animal charcoal, while white spodium consists of "Bone ash" (q. v.).

Spodium manufacturing plants:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Stagnine. An astyptic obtained from the spleen. It has no ferment action since its properties are not destroyed by evaporation.

Stains, Removal of.

GREASE STAINS. The articles are usually cleaned by subjecting them to treatment in revolving drums with benzine or benzine vapours. Grease can also be removed from textiles and linen by washing with soap and sodium carbonate (or caustic soda), and from coloured materials by rubbing with

benzine, or a mixture of benzine and ammonia. After saturating the material on both sides of the spot with the chemical, it is laid between blotting paper, and then ironed. A specially strong and powerful agent is formed by mixing alcohol, ether and ammonia or by making into a paste benzine and magnesia. Benziniform or carbon tetrachloride (q. v.) is an excellent substitute for benzine as is not inflammable.

A good mixture for removing stains caused by fat or grease consists of 20 parts of a solution of soap in alcohol, 10 parts of a 10 % solution of ammonia and 3 parts of acetic ether. Another equally good mixture consists of 20 parts of benzine, 4 parts of ether, 3 parts of acetic ether and 6 parts of turpentine oil. An ammonia soap is made as follows:—50 ccm of oleic acid, 25 ccm of ether, 25 ccm of chloroform, 250 ccm of benzine and 50 ccm of a saturated solution of sal ammoniac in alcohol are mixed in the same order as given above with constant shaking (WILBERT). If a white emulsion is preferred the spirit can be replaced by the same quantity of water or even by double the quantity.

2. BLOOD. Removed by washing with a cold solution of soap and Na_2CO_3 .

3. CHOCOLATE STAINS. These spots must first be treated in the same way as grease stains, then rubbed with yolk of egg and finally rinsed with water containing Na_2CO_3 . Glycerine can also be used for this purpose. The spots are simply rubbed with a sponge soaked in glycerine and then washed with water or methylated spirits.

4. COFFEE STAINS. Dichlorhydrin and epichlorhydrin are said to be very effective for removing coffee stains. Compare the article on "CHLORHYDRINES". These chemicals are used cold. Glycerine is also a very good agent for removing the remaining traces of strong coffee. See "CHOCOLATE STAINS" No. 3.

5. STEARINE STAINS. These stains can be removed with a hot flat iron.

6. FRUIT, WINE, AND GRASS STAINS. These can be removed with a mixture of 9 parts of a 2 % solution of hydrogen peroxide, 1 part of ammonia and 20—30 parts of H_2O . Hydrogen peroxide will take out such stains from silk, copper plate engravings &c. Wine and vinegar stains can also be removed with a mixture of 16 parts of soap, 2 parts of turpentine and 1 part of ammonia.

7. COLOUR STAINS can be removed from white goods by a dilute chlorine solution. Eau de Javelle, diluted with water is an excellent agent. Compare "BLEACHING".

8. GRAVY AND SAUCE STAINS. Stains made by greasy sauces are first treated with benzine and then with warm concentrated solution of oxalic acid, after which the soiled spots are washed with ammonia, and repeatedly rinsed very carefully with water.

9. INK STAINS. Spots made by pure iron-gall ink should be treated with a concentrated solution of oxalic acid and then covered with tin filings. After standing for some time the article must be very carefully washed in warm water because if any of the oxalic acid be left in the material it will destroy the fibre or tissue after drying.

Spots made by alizarin ink should be first washed in water, then covered with powdered tartaric acid and allowed to stand for some hours; after which the article should be rinsed with water and finally bleached with Eau de Javelle. A very reliable method for removing stains made by aniline inks is a mixture of 60 parts of spirit of camphor, 175 parts of an alcoholic solution of soap and 12 parts of ammonia, with an addition of 1 part of oil of thyme and 2 parts of oil of rosemary if desired.

10. RAIN SPOTS. These stains can be removed from velvet by first moistening with distilled water, then with a little ammonia, and finally drawing the velvet carefully over a warm iron or allowing steam to pass through the fabric to raise the pile. In each case of course the pile must be held upwards and should on no account come into contact with the iron.

11. **IRON MOULD AND INK STAINS ON LINEN.** A tin plate containing a not too dilute aqueous solution of citric acid, and common salt, is put over a vessel full of boiling water, and the stained material is then laid in the mixture. After the spots have disappeared the article must be well washed. If instead of the tin plate a China one should be used, a little stannous chloride must be added to the mixture.

12. **TANNIN AND TANNIC ACID STAINS ON LINEN.** These are removed by means of lead acetate, or they can be converted into ink with ferrous sulphate and then treated according to the method given for ink stains in No. 9.

13. **POTASSIUM PERMANGANATE OR CONDY'S FLUID STAINS.** These stains can be removed from white materials by means of weak HCl solution or by treating them with ammonium sulphide and then carefully rinsing in warm H_2O . A solution of oxalic acid will serve the same purpose. These stains can be removed from the skin in the same way.

14. **IODINE STAINS.** These can be removed by treating with ammonia or with potassium cyanide solution.

15. **ACID STAINS.** These stains can be removed by treating them with liquid ammonia and then carefully rinsing in water. Stains made by nitric acid cannot be taken out.

16. **CAUSTIC ALKALI STAINS.** Stains caused by lime can be removed by treating with acetic acid.

17. **SILVER STAINS** should be first soaked in a solution of potassium cyanide and then washed with a solution of sodium thiosulphate, or the stains can be treated with a potassium iodide solution of iodine and afterwards washed with ammonia.

18. **TAR STAINS.** Tar can be removed from textiles by treating with a mixture of alcohol and benzine. The following method is highly recommended. The soiled spot is well rubbed with lard or unsalted butter and then warmed until the tar and fat become liquid; the mixture is then rubbed off with oil of turpentine, the spots washed with a 10 % aqueous solution of ammonia and then rinsed with luke-warm water. If necessary this procedure must be repeated several times until the spots have completely disappeared.

19. **COAL-TAR DYE STAINS.** These can generally be removed from white goods by repeated treatment with a weak solution of potassium permanganate, 1 : 1000, the article is left in the solution for several hours each time. The brown spots which remain entirely disappear on washing in a warm solution of oxalic acid.

Stamping mills.

Stamping mills:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.

Starch. A vegetable product belonging to the group of carbohydrates. It is prepared commercially from potatoes, wheat, maize, rice and other plants. The process consists in stripping off the husk and then making a suspension of the starch grains in water. Soft, pure, clear water, free from iron is essential to the process.

In the preparation of potato starch, the potatoes which contain about 20 % starch are first washed and crushed fine by machinery. From the pasty mass thus obtained which contains in addition to the starch, cell-sap and

cellulose, the starch is washed out with water. Brushes are used to facilitate the removal of the starch grains from the unbroken cells. The starch is thus obtained in a milky state and separated from the residual fibrous matter which is used as a cattle food and for the preparation of glucose.

The brush (extracting) machine is well adapted for this purpose. The brushes are arranged spirally round the axis of the machine and cause the potato pulp to move from one end to the other. The cellulose constituents are separated by sieves of varying degrees of fineness and the milky starch suspension runs through into large cemented tanks where the starch sinks to the bottom. Troughs inclined at a low angle are preferable for this purpose. The starch milk is stored in tanks provided with stirring apparatus and is pumped into these troughs where the starch settles more quickly than in tanks: the product thus obtained is of a better (whiter) quality. The crude starch is washed in tanks with pure water, again allowed to settle, the supernatant liquid removed, and the upper layer of starch, which is impure and of a grey colour, scraped off. By a repetition of the process a perfectly pure product may be obtained. The process of purification has recently been improved by the introduction of centrifugal methods, which are also applied for drying the "green" starch (45 % H_2O). The further drying is carried out on basket-work frames or in a drying apparatus. In some forms of apparatus the starch during drying is kept in constant motion, the product in this case being obtained in the form of a flour and not as is usual in lumps. The flour is sometimes further ground. During drying the temperature must not rise above 60° or the starch will become dusty.

The so-called STARCH GLAZES are made of potato starch to which borax or finely-powdered stearic acid is added. To prepare artificial sago the moist starch is rubbed through sieves with a 3—5 mm mesh, the granular masses are dusted with dry starch and run in rotating drums. The grains are then sorted, placed on trays heated to 100° in a room until a glaze is formed, and then dried at a lower temperature.

In the preparation of wheat starch the presence of adhesives makes the separation of the starch more difficult. To remove the gummy matter the wheat is steeped, crushed, and fermented. (Sour dough or yeast is added for the last-named purpose.) At the end of the fermentation process the mass is treated first with water in washing drums and then as described above.

It is more economical to obtain the gummy matter by a "sweet" process. The wheat is steeped, crushed, and then immediately washed in special apparatus. This results in the breaking apart of the tough gum and the starch by means of jets of water. The starch is obtained either by allowing to settle, or by centrifuging and drying. Wheat contains 58—64 % starch and 10 % gum.

In the preparation of rice starch bruised rice is generally used. In order to quicken the process the rice is steeped in dilute caustic soda lye. The grains are ground wet and caustic soda again added. The starch is washed through a sieve on which the fibrous matter remains. The further treatment is as described above. Rice contains 70—75 % starch.

Maize starch is obtained by steeping the maize in pure water or in water containing SO_2 at 40 — 50° , separating the embryo mechanically, grinding the maize in mills, stirring with water and separating the starch from fibrous matter by brushing through sieves. The impurities are removed by washing. Maize contains on an average 59 % starch.

Starch is used for many different purposes, e. g. as a food, for dressing fabrics, for making cosmetics, in paper manufacture, as a thickening in the printing of textiles, for making gum, for laundry purposes and in the manufacture of dextrine and glucose.

Starches soluble in water may be obtained in various ways; e. g. a white powder soluble in water may be obtained by adding to the gelatinous mass obtained by boiling starch with water. A starch solution may be prepared by stirring powdered starch with caustic soda lye. Starch may also be rendered soluble by stirring with water and then warming with malt. H_2SO_4 or bleaching powder may be used instead of malt. In order to obtain a thin and at the same time efficient starch solution 25 kg starch flour are stirred with cold water and diluted to 100 litres. 12 litres of a solution of bleaching powder (5—6° Bé) are added and the whole heated to boiling. The boiling is continued for 25 minutes to allow the Cl to escape. Only at the end are various additions made (glue, fat, &c.),

Germ. Pat. 134301 protects a method for making starch soluble by means of persulphates.

100 kg of starch flour are mixed with 3—5 kg of ammonium persulphate and 150 litres of cold water and allowed to stand at the ordinary temperature for 10 hours (with occasional stirring). Oxygen is evolved ($(\text{NH}_4)_2\text{S}_2\text{O}_8 + \text{H}_2\text{O} = 2(\text{NH}_4)\text{HSO}_4 + \text{O}$) which in the nascent state acts upon the starch and makes it soluble. The solution is poured off, filtered and washed until all the ammonium sulphate is removed. The starch is then dried. The product gives a clear solution with hot water which solidifies on cooling to a gelatinous mass. The substance is used in the dressing of textiles.

According to Germ. Pat. 137330 the starch is warmed with a 1 % solution of a liquid organic acid (formic or acetic acid) for 5—6 hours at 115° and then the excess of acid is removed by distillation. The advantage of the use of volatile acids over the use of non-volatile acids is that subsequent neutralization is unnecessary. The method of Germ. Pat. 182558 in which dry starch is heated with acetic acid is similar to the above.

Germ. Pat. 149588 (and suppl. 168980) deal with the preparation of a starch soluble in boiling water by treating the starch with chlorine gas and then heating the mass to 100°.

According to Germ. Pat. 156148 the material containing starch is treated with excess of KMnO_4 (more than 1.5 %) at a temperature not exceeding 50° until all the starch has been converted into a soluble form.

Soluble starch may also be made (Amer. Pat. 773469) by heating powdered starch to 62—63° and then heating at this temperature with a suitable acid (best with HCl) in the form of vapour.

Germ. Pat. 157896 protects a method for the preparation of a starch which swells up in cold water. The starch is stirred at a temperature between 10° and 30° with as much methyl or ethyl alcohol (50—80 %) as is necessary to make it into a thin milky liquid, in which the starch is kept in suspension by stirring. For every 100 kg of this mixture, 40 kg of caustic soda lye (30° Bé) is added and the whole becomes pasty. After a few hours some acid (e. g. acetic acid) is added, the starch pressed out of the alcoholic salt solution, dried and finally ground. When the product is treated with ten times its amount of water it swells up in a short time to a paste-like mass. This product is very suitable as a substitute for various technical purposes, e. g. dressing of textiles and the manufacture of pastes (adhesives).

According to Germ. Pat. 166259 starch is mixed with a warm solution of Na_2SO_4 , a mixture of NaOH and Na_2SO_4 solutions added, pressed after standing for ten minutes, and the starch then dried and powdered. The product swells up and becomes pasty on addition of H_2O .

According to Amer. Pat. 813647 soluble starch may be made by mixing dry starch and dry bleaching powder with NaHCO_3 (?).

According to Germ. Pat. 179509 compounds of starch and formaldehyde may be obtained in presence of an alkali. These FORMALINE STARCHES should prove of use as disinfectants, in medicine and in the textile industry.

TEST. The nature of the starch (wheat, rice, &c.) must be determined by microscopic investigation.

The water is estimated by heating 10 g starch for an hour to 40–50°, then for four hours to about 120° and weighing after cooling in a desiccator. It is important that the first heating should not take place above 60° or the starch becomes paste-like. Good starch should not contain more than 20 % water.

If acids are present SAARE recommends their estimation as follows: — 25 g starch are stirred with 30 ccm H₂O to form a thick paste. This is then titrated with N/10 NaOH until a drop of the solution placed on a filter paper folded several times is no longer coloured red by litmus. A control experiment is also carried out using neutral starch. If for 100 g of starch 5ccm N/10 NaOH are necessary, the starch is described as slightly acid, if 8 ccm, as acid, and if more than 8 ccm as strongly acid.

The adhesive power is best determined according to SCHEIB by mixing the starch with water and boiling over a BUNSEN burner until the paste is transparent and begins to froth. The burner is removed and the paste well stirred. With a normal starch, 4 g and 50 ccm of water give a paste which sets on cooling and cannot be poured out of the dish. The heating must not last for more than a minute.

Other impurities are estimated in the ash or in the residue left after dissolving out the starch. Or the starch may be brought into solution by boiling with water and then treating for 2 hours with normal malt solution (100 g malt in 1 litre water) at 65°. The solution is then treated with HNO₃.

Starches:

R. Preston & Co., Bury, Lancs.

Manufacturing apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Soluble Starches:

Louis Blumer, Zwickau Sa., Germany.

Steam turbines. Steam turbines have lately caused considerable interest. They are already occupying a prominent position amongst motors, and it is even conceivable that they will entirely replace the old piston machine in certain well defined directions, e. g. in working electric generators, and consequently in many branches of chemical industry, in which the importance of electricity is increasing from year to year.

The principle of steam turbines is that the steam is forced against the blades of a wheel thus causing it to rotate.

The arrangement of the PARSONS' turbine is such that the blades form a number of systems arranged concentrically about a horizontal axis. This arrangement of a larger number of systems on a common axis is the cause of the relatively small number of revolutions in PARSONS' turbine, as the various systems have to share the total pressure, or total velocity of the steam, each system utilizing only a fraction of the total pressure, or velocity of steam and transferring it to the axis. In order that a rotating movement should ensue it is not sufficient to apply a certain steam pressure; the steam must have a certain direction, so as to strike the blades in the proper way. For this purpose the PARSONS' steam turbine possesses a second system of blades, rigidly mounted inside a cast iron cylinder, and in such a way that the various rings correspond to each other leaving a space of 3–4 mm between.

Numerous impartially-conducted experiments have shewn that good steam turbines can compete with the best piston machines, in economy as well as in power.

Steam, superheated. The object of superheating steam is to effect a smaller consumption of steam for a certain amount of work done by an engine. The steam must be prevented from condensing in the pipes and cylinders on entering. A considerably smaller amount of steam is also necessary when it is superheated for cooking-, heating-, and drying purposes. In these cases moist steam is mixed with superheated steam, the object being to avoid loss by condensation. The efficiency of this process is based on the fact that moist steam condenses rapidly in the long pipes in consequence of its low temperature, while superheated steam, also at a lower pressure, does not condense before dropping to the temperature of the moist steam. Another point worthy of notice is that the exhaust steam of machines working with superheated steam is of much more use in heating and drying. When strongly superheated this exhaust steam is even sufficient for boiling purposes in paper mills, chemical works, &c.

As the heating gases of the boiler are better utilized by conveying heat to the wet steam flowing through the superheater built into the flue, and as the effect is heightened by enlarging the volume of the steam by superheating, (or, as a smaller amount of steam is then used) the economy of steam, or the corresponding economy of coal with a good superheating apparatus and proper arrangement reaches as much as 30 %.

Additional heat increases the volume of the steam without changing the pressure; the volume increases with the temperature of the steam. When the pressure is 10 atm. (= 183%), the volume increases by

about	18 %	by an increase of	70° C = 253° C,
"	22 %	" " " "	" 100° C = 283° C,
"	33 %	" " " "	" 150° C = 333° C.

Therefore the steam required diminishes by the same amount as the volume is increased, since for the same effect, a quantity or weight of steam is used smaller in proportion to the increase of the volume. Another advantage is the absence of condensation, so that the entire saving of coal due to saving of steam is 15—30 % according to the conditions and the degree of superheating. An additional convenience is that the machine is working with practically dry steam, so that the danger caused by the presence of water is avoided.

The best and most effective manner of superheating is to build suitable apparatus into the flues, either into the first, or between the first and second so that sufficient heat may surround the superheater.

Steam engines:

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Steam apparatus in metal and in all sizes:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Steam apparatus:

Friedrich Heckmann, Berlin SO, 16, Brückenstr. 6b (see advts.).

Stearine. A triglyceride of stearic acid which together with palmitine and oleine is found in most fats. The commercial stearine is a mixture of stearine and palmitine from which the oleine has been removed. Tallow, palm oil, coconut oil, dripping, &c., are melted and allowed to cool very slowly: the oleine is then removed by pressure: the melting and the pressing are repeated several times.

The removal of the oleine by this method is only partial: much more complete is the separation involving the saponification of the fats, melting the fatty acids so obtained, allowing them to cool and then separating the liquid oleic acid from the solid stearic and palmitic acids by hydraulic pressure. Such a mixture is known commercially as stearine.

The modern method of saponification is to heat the fat in autoclaves with lime, or better with magnesia (2 %) at a pressure of 9 atmospheres: the fatty acids are then separated from the magnesium soaps by boiling with dilute sulphuric acid and drying at 105—110°. In order to remove impurities and to decompose unaltered fats the dry fatty acids are treated with 2 % of sulphuric acid (66° Bé), the acid removed by washing, the fatty acids dried and then distilled.

At first the pressure is applied cold and then at a temperature of 35—40°. The hard, white cakes are then cut at the edges (since they still contain oleic acid, q. v.) melted over sulphuric acid and the acid finally washed with water. If the stearine is required in a pure state it must be recrystallized from alcohol or some other solvent.

In the large American slaughter-houses the fat is melted, stirred with petroleum ether to a paste and the oleine removed by pressure.

The stearine is then recrystallized several times from petroleum ether, and is sold in two grades.

A series of methods has been proposed for converting liquid into solid fatty acids (see "FATTY ACIDS") Almost the whole of the stearine produced is used in the preparation of candles. Glycerine is the usual by-product.

Stearine-manufacturing apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Stearine pitch:

Voigt & Co., Dresden-N.

Steel. Iron containing 0.4—0.5 % carbon either as hardening carbon or as iron carbide Fe_3C . Steel is malleable and can be welded and tempered; M.P. 1300—1800°. We have to distinguish between steel obtained in non-liquid condition and ingot steel, MARTIN steel, BESSEMER steel, &c.) obtained in a liquid state. Further details see under "IRON", "INGOT IRON" and "WROUGHT IRON".

Steel is refined by remelting, when it is called "cast steel".

See also "IRON ALLOYS".

Experiments for making steel directly from the ore by electrical methods are gaining importance.

The most important methods of producing steel in electric furnaces are those of STASSANO, HEROULT, KELLER and KJELLIN. These and other methods may be divided into two classes, the first containing those which work with carbon electrodes; (e. g.) STASSANO, KELLER, HEROULT, HARMET and COULEY. The second class consists of those in which carbon electrodes are not used (KJELLIN, GIN, GIROD and RUTHENBURG).

The oldest process is probably STASSANO's (Germ. Pat. 141512). High percentage iron ores made into briquettes with charcoal &c. are smelted in the electric arc of 1 m length (at 2000 amperes and 170 volts alternating current). The furnace used is now similar to a MARTIN furnace; there are three pairs of electrodes reaching into the furnace from the side and not coming into contact with the ore. In STASSANO's process the mixture of ore, carbon and limestone must be finely powdered, and in a proportion corresponding exactly to the composition of the ores. Recently rotating furnaces have been successfully used by STASSANO.

In KELLER's process (Germ. pat. 122271) two furnaces are built one over the other. The upper produces crude iron from ore, i.e. acts as a blast furnace though the required temperature is obtained by electricity instead of by coke. The pig iron from this resistance furnace is then refined in the lower one. When the pig iron is prepared in the ordinary blast furnace, the resistance furnace is of course not used.

HEROULT prepares tool steel by smelting a mixture of cast iron and steel chips in furnaces turning like BESSEMER vessels, heated by two alternating current arcs (each of 60 volts 4000 amp).

HARMET's process (Germ. Pat. 142763 and 143111) and that of the *Syndicat de l'acier Gerard* also involve the use of pig iron; the gases rich in CO escaping from the mouth of the electrothermic furnace are drawn off and re-introduced from below and again take part in the reduction of the ore.

The most elegant and probably most hopeful process for preparing steel electrically is that of KJELLIN (Germ. Pat. 126606). A mixture of cast and wrought iron is used without carbon electrodes; the furnace consists of a transformer in which the liquid steel takes the place of the secondary coil, (high current intensity and low voltage) while the primary coil receives alternating currents of small intensity. In Gysinge (Sweden) this method is already used on a large scale; the most important feature is that the steel produced by KJELLIN's method is of excellent quality (equal to crucible steel.)

In the method of G. GIN (Germ. Pat. 181888) the furnace consists of a smelting chamber in which purification and oxidation are carried out simultaneously, a second chamber for deoxidizing and carbonizing, and a third in which the final composition of the steel is regulated.

The electrodes in the first compartment are connected with one of the poles, and those of the other two connected in parallel with the other pole. The current passes from the electrodes to the metal through a layer of fused slag floating on the surface, and the resistance due to this is sufficient to give the JOULE effect. In the first compartment the slag is oxidizing, in the others it is neutral. Fused pig iron is introduced, it distributes itself through the three compartments which are connected by canals, the current is passed and the electrodes raised or lowered as required.

A new induction furnace (Hiorth's system) consists essentially of two Kjellin furnaces placed side by side.

RUTHENBURG's method (Germ. Pat. 138659) does not yield liquid metal. It may be used for fine-grained or powdered ore unsuitable for treatment in the usual blast furnaces. The ore runs down between two roller-shaped electromagnets covered with a layer of retort graphite and revolving slowly. The carbon layer is connected with an electric current which passes through the ore. The latter becomes hot, melts or sinters and drops into a pit; it is now ready for the usual furnace treatment, and is improved considerably by having lost a certain amount of sulphur and phosphorus.

The other methods of producing steel by electric methods are less important and are omitted in detail though mentioned above.

A Canadian commission has lately inquired into the most important of these processes at the places of their application. According to their estimate the current used in the steel processes is the following:

HEROULT process 1100 and 718 K. W. hours	} per ton of steel.
KELLER process 804 K. W. hours	
KJELLIN process 832 and 1040 K. W. hours	

The current used in preparing pig iron by the same process is:—
 HEROULT-process 3380 K. W. hours.
 KELLER process 3420 K. W. hours.

They conclude that crucible steel may be prepared in electric furnaces which is just as good and is cheaper than that obtained by the usual processes. The electric preparation of ordinary steel for construction purposes cannot compete with the BESSEMER and MARTIN process. The electrical production of pig iron could compete with usual methods only in districts where electricity is very cheap and coal very dear.

Steel plating. This method is generally employed for increasing the durability of copper plates and clichés. The very thin light grey iron film possesses the hardness of steel and retains all details of the original plate.

A suitable steel bath is 26g pure ferrous sulphate and 12g pure ammonium chloride, dissolved together in 1 l. distilled H_2O . The anode is an iron plate; the distance between the anode and the cathode to be steel-plated is as a rule about 5 cm. The current density for steel plating is not very great, as a rule 0.02 amperes per sq.dm. The voltage should be 1.0—1.25 volts at first and when a fine film has settled 0.7—1 volt. A deposit 0.01 mm in thickness requires about 30 hours.

A steel bath recommended by R. NAMIAS consists of 40 g ferrous sulphate with 100 g ammonium chloride in 1 l. water; it is well to add 100 g ammonium citrate so as to prevent a basic iron salt from separating, especially on the anode.

According to Germ. Pat. 137325 a steel bath is prepared by boiling iron or steel turnings with a solution of KBr and NH_4Cl for 4 hours: the anodes are plates of cast iron.

Stirring Apparatus.

Stirring apparatus and stirring boilers of metal:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Stirring-Plants:

Wegelin & Huebner A.-G., Halle a. d. S., Germany.

Stomosan. Trade name for ethylamine phosphate. It is said to be used medicinally.

Stones, artificial. The manufacture of artificial stones is connected to a certain extent with the production of "MORTAR" and "CEMENT" (q. v.), because artificial stones are substances made from stones of various kinds, the refuse of various industries, &c. by combining them with some adhesive into a solid mass; the adhesive employed in most cases is either mortar or cement. The materials employed as bases for artificial stone are glass fragments, slags, flints, lava, refuse slate, sediments, broken marble, gypsum, powdered brick and so on.

The different kinds of artificial stones are classed according to the adhesive used under the following heads:—

1. Stones with air, water or gypsum mortar.
2. Artificial stones with magnesium cement as adhesive.
3. Artificial stones with water glass as adhesive, and
4. Artificial stones with an adhesive of organic nature.

Lime sandstones are the most important of that class in which mortar is used as the adhesive. Compare for details the article on "SANDSTONE". The material known as Beton (q. v.) should also be mentioned here; the adhesive employed is in this case cement.

So very many novelties in the way of artificial stones continually make their appearance that it is impossible to consider them all. On the whole, however, in a few cases only is there anything really new to report.

Attempts have been made for some time, especially in America, to make artificial stones with magnesium cement. Magnesite is burnt at a low temperature, and ground sand is added so that the mixture contains about 10 % of MgO . $MgCl_2$ solution of 20—30° Bé is used for mixing. The product is pressed into the required form and the stones can be used for building purposes after the short space of one week.

According to Germ. Pat. 56057 artificial stones are made by intimately mixing 100—150 parts of freshly precipitated caseine with 50—60 parts of

calcium and magnesium hydroxides, 10—20 parts of glycerine, 10—20 parts of potash or soda waterglass and 5—10 parts of drying oil, adding sufficient shavings to make a thick paste. The substance is then compressed into the desired shape dried at 20—30° and finally ground and polished.

The organic substances used as adhesives are tar, asphalt, and resin.

There are many methods known for making artificial marble. One method is that of burning common plaster of Paris as slowly as possible. This durable product is very firm and of fine crystalline consistency. Another form of plaster marble is composed of equal parts of gypsum and sharp sand. The mixture is stirred up with glue and coloured with the ground tone of the marble it is intended to imitate. A material resembling marble is also made from plaster by adding pure gypsum to the substance and adding different kinds of colouring matter. After the substance is dry and hard the rough inequalities are taken off with a plane, after which it is polished first with coarse and then with fine sandstone or polishing stone till the surface is quite smooth and bright. According to Germ. Pat. 138689 marble, onyx and coloured stones are made as follows: A solution of alum in water is added to a mixture of heavyspar and colouring matter previously moistened with H_2O ; it is then cooled with continual stirring and finally poured into moulds. About 1000 parts of alum are dissolved by heat in about 100 parts of water; as soon as the solution begins to boil 10—100 parts of heavyspar mixed well with pigment and water are added; the whole is then evaporated until it has lost about 3 % of its weight, when it is allowed to cool with continual stirring to a thick fluid. The product is then poured into moulds lined with several coatings of collodion and left to solidify. Onyx is imitated by previously adding coloured pieces of alum to the above mixture during the process.

The following later patents for the production of artificial stones should also be mentioned. Artificial stones made of slate are, according to Germ. Pat. 144284, obtained by moistening finely powdered slate with dilute hydrochloric or nitric acid, treating the mixture with steam, pressing into moulds, drying the stones in the air and finally hardening them by means of compressed steam.

Germ. Pat. 144352 and 144457 give particulars for the production of artificial stones from rubble and tar by special methods.

According to Germ. Pat. 146244 unburnt gypsum together with some mineral containing magnesium silicate is added to molten waterglass, after which the mixture is moulded to the required shape and the stones brought to a red heat.

Germ. Pat. 149135 protects a process for making stones by mixing Permian limestone and cement with a small quantity of magnesia moistened with water. The mixture is poured into moulds, and the stones afterwards dried in the air. It is stated that it is unnecessary to harden them by treating with steam.

According to Germ. Pat. 151252 concentrated hydrochloric acid is allowed to act upon magnesia after which the acid is neutralized with excess of magnesia, and finally some sort of filling such as ground asbestos is added.

Germ. Pat. 152190, supplement to Germ. Pat. 138058, protects a method of making stone by mixing sand or slag rich in silica, slaked lime and the residues from the soda industry, in vertical mills, with a plentiful supply of water, pressing the product into moulds and then hardening by means of compressed steam.

Germ. Pat. 154625 makes use of a strongly compressed mixture of superheated steam and purified furnace gases for hardening plastic substances made of slag, peat, straw and refuse wood, sand and slaked lime.

According to Germ. Pat. 154750, fire-proof articles are made from a mixture of powdered chrome ore with fire-brick dust and aluminium hydroxide. After being moulded, stones made of this mixture are burnt.

Germ. Pat. 154975 protects the preparation of sand stones in which the adhesive is magnesia instead of lime.

Artificial granite (Amer. Pat. 776460) is made by adding powdered mica and a coloured oxide to molten glass and then devitrifying by very gradually cooling the casting.

According to Germ. Pat. 159469 good fire proof materials can be made from aluminium hydroxide with quartz or fireclay. This patent differs from the previous one only in the omission of the chrome ore.

Germ. Pat. 161641 protects a very original method for producing porous stones by adding fragments of ice to the mixture of cement with slag sand or gravel or gypsum with slag, &c. The mixture containing the ice is pressed into moulds and as the ice at once begins to melt this process is supposed to make the product porous (?). Germ. Pat. 162858 protects another method for making stones of sand and chalk, with fatty substances such as linseed oil varnish, fat or wax as adhesives. The material is allowed to become almost dry as a loose powder in the air. It is then formed into stones which are finally hardened by heating to 120—180° for 24 hours.

The product which comes on the market under the name of wood stone or xyolith is treated of in the article on "WOOD, ARTIFICIAL".

Compare also "PLASTIC SUBSTANCES".

Stone breaking machines:

W. Stamm, 25 College Hill, London E.C., Sole agent for Friedr. Krupp A.-G. Grusonwerk, Magdeburg-Buckau, Germany.
Max Friedrich & Co., Leipzig-Plagwitz 17.

Stoneware. Goods of stoneware are porous structures covered with a glaze. The following kinds are distinguished:—

1. Fine fayence;
2. Common fayence or majolica;
3. Crockery ware.

English stoneware of fine fayence has transparent glazes, either colourless, in which case the underlying colour is visible, or coloured when the body colour appears translucent. The glaze of majolica is opaque (due to SnO_2) and is either white or coloured. The colouring is brought on to the glaze and then burnt in.

For the preparation of stoneware a greasy clay which burns white is mixed with quartz or a finely-ground fire-clay. The proportions vary:—clay from 35 to 65 %, quartz 35 to 60 %. The glazes, which are burnt in at a much lower temperature than is used for firing, are either lead alkali silicates or in the case of leadless glaze, boric acid glazes.

In the manufacture of majolica the alluvial matter is washed and freed from coarse stones and mixed with the requisite quantity of chalk and sometimes with fine yellow sand (to thin down the clay). The mixture contains from 25—40 % CaCO_3 . The glazes consist of lead silicates made opaque by the addition of SnO_2 .

Stoneware Vessels:

Fr. Chr. Fikentscher Ltd., Zwickau Sa., Germany (see front part advt.).
Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Stopcocks.

Stopcocks of stoneware:

Fr. Chr. Fikentscher Ltd., Zwickau Sa., Germany (see front part advts.).
Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Stopcocks of metal:

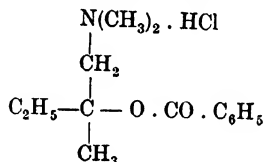
Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).
Friedrich Heckmann, Berlin SO. 18. Brückenstr. 6b (see advts.).

Storax. A balsam resembling turpentine obtained from the bark of *Liquidambar orientale* (native to Asia Minor and Syria). It is prepared by extracting and pressing the bark with water.

The liquid storax so obtained is a tough brown mass which dries very gradually but always remains sticky. It is purified by warming on the water bath, dissolving in alcohol, filtering and evaporating the solution. It is used in medicine and in perfumery. It contains large amounts of esters of cinnamic acid, free cinnamic acid and benzoic acid (styrol and styrazine).

The so-called solid or red storax (*Styrax calamita*) is a synthetic product obtained by compressing a mixture of a poor quality of storax and sawdust. It is a brownish-red crumbly mass used in the preparation of pastilles and disinfectant powders.

Stovaine = the hydrochloride of benzenedimethylaminodimethylethylcarbinol.



A white crystalline powder M. P. 175°, readily soluble in H₂O and methyl alcohol, less so in alcohol, almost insoluble in ether. It is a local anaesthetic, important as a substitute for cocaine, as it is very effective and much less toxic than cocaine itself.

Strass. This is a kind of glass (q. v.) used to imitate precious stones. The name is due to the inventor, J. STRASSER, a Viennese goldsmith. Strass contains more than 50 % of lead oxide. The materials used must be very pure. For colourless strass (imitation diamonds) a mixture of 100 parts sand, 40 parts minium, 24 parts K₂CO₃, 20 parts borax, 12 parts saltpetre and 0.4 parts manganese dioxide is used.

Coloured stones are obtained by fusing colourless strass with metallic oxides, the quality of the product depending upon careful mixing and melting and various details. According to DONAULT the following are the mixtures, imitating:

Emerald	1000	parts.	strass, 8 parts CuO, 0.2 parts Cr ₂ O ₃ .
Amethyst	1000	" "	8 parts Mn ₂ O ₃ , 5 parts Co ₂ O ₃ , 0.2 parts purple of Cassius.
Sapphire	1000	" "	15 parts Co ₂ O ₃ .
Topaz	1000	" "	40 parts antimony glass, 1 part purple of Cassius.
Ruby	8	" "	and 1 part of the topaz mixture.
Garnet	1000	" "	500 parts antimony glass, 4 parts purple of Cassius and 4 parts Mn ₂ O ₃ .

Strontium. Sr. A. W. = 87.62. Occurs in the minerals strontianite SrCO₃ and celestine SrSO₄. The metal which resembles brass in colour is obtained by the electrolysis of fused SrCl₂ in presence of NH₄Cl. According to BORCHERS

and STOCKEM it may readily be prepared by the electrolysis of fused SrCl_2 when the wall of the cell is the anode and a small iron cathode is introduced from below into the fused mass. With suitable cooling arrangements the Sr can be obtained in balls 10 mm in diameter. They form on the cathode and can be removed from the cooled melt.

Sr can also be obtained by heating strontium amalgam in a current of hydrogen: the amalgam is obtained by plunging sodium amalgam into a hot saturated aqueous solution of SrCl_2 . The metal decomposes water at the ordinary temperature, oxidizes in the air and when ignited burns with a red flame. It has no technical value.

Strontium compounds.

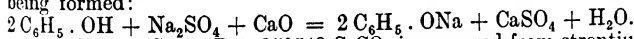
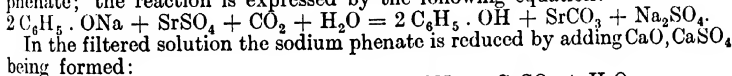
1. STRONTIUM ACETATE. $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$. Obtained by decomposing SrS or SrCO_3 with acetic acid.

2. STRONTIUM CHLORATE. $\text{Sr}(\text{ClO}_3)_2$. SrCO_3 is suspended in H_2O and Cl introduced. Electrolytically it may be prepared in a manner analogous to that used in preparing barium chlorate (see No. 4 "BARIUM COMPOUNDS"). It is used in pyrotechny to give red effects.

3. STRONTIUM CHLORIDE. SrCl_2 . Obtained on a large scale by treating SrS with HCl and evaporating to crystallization. With $6\text{H}_2\text{O}$ it forms colourless crystals, very soluble in H_2O . It is also used in pyrotechny.

4. STRONTIUM HYDROXIDE, see No. 8 "STRONTIUM OXIDES."

5. STRONTIUM CARBONATE. SrCO_3 . Occurs naturally as strontianite, obtained artificially by treating SrS with CO_2 , or from strontium salt solutions by precipitation with alkali carbonates; also by melting SrSO_4 with Na_2CO_3 or (Germ. Pat. 120317 and 121973) from SrSO_4 by the action of CO_2 and an alkaline carbonate under pressure. According to Germ. Pat. 131566 SrCO_3 is obtained from SrSO_4 by treating the latter with CO_2 in a solution of sodium phenate; the reaction is expressed by the following equation:



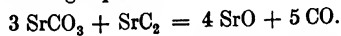
According to Germ. Pat. 150543 SrCO_3 is prepared from strontium residues by converting the strontium of the raw material into SrCl_2 by means of MgCl_2 . The MgO formed is separated after extracting the SrCl_2 and is used together with CO_2 to convert the SrCl_2 into SrCO_3 ; the process is evidently a complete cycle.

6. STRONTIUM NITRATE. $\text{Sr}(\text{NO}_3)_2$. Obtained by treating SrCO_3 or SrS with HNO_3 and evaporating to crystallization. White anhydrous crystals, readily soluble in H_2O , scarcely soluble at all in absolute alcohol; it also crystallizes with $4\text{H}_2\text{O}$ in efflorescent crystals. Used in pyrotechny.

7. STRONTIUM OXALATE. SrC_2O_4 . Obtained by precipitating solutions of strontium salts with oxalic acid.

8. STRONTIUM OXIDES.

a) STRONTIUM OXIDE SrO . Obtained by heating $\text{Sr}(\text{NO}_3)_2$ to a white heat; it may also be prepared from SrCO_3 . According to Germ. Pat. 135330 SrO is produced by reducing Sr salts (especially SrCO_3) with strontium carbide, the materials being mixed and heated in absence of air; the reaction is expressed by the following equation:



b) STRONTIUM HYDROXIDE $\text{Sr}(\text{OH})_2$. It is as a rule prepared from SrSO_4 by converting the latter into SrS, extracting this with H_2O and treating the solution with copper oxide. It is also obtained by slaking SrO with small amounts of H_2O . By a patented electrolytical method for the preparation

of $\text{Sr}(\text{OH})_2$, SrCl_2 is decomposed, a soluble metallic anode being used. $\text{Sr}(\text{OH})_2$ is a powerful base, dissolving in water with evolution of heat, and crystallizing from a hot saturated solution with $8 \text{ H}_2\text{O}$.

Strontium hydroxide is important as a means of extracting the sugar in molasses (see "MOLASSES").

c) STRONTIUM PEROXIDE. SrO_2 . Hydrates of this compound are obtained by the action of hydrogen peroxide on an aqueous solution of $\text{Sr}(\text{OH})_2$. When strontium peroxide hydrate is heated to 100° the H_2O escapes and SrO_2 remains as a whitish powder.

9. STRONTIUM SULPHATE. SrSO_4 . Occurs naturally as celestine, obtained artificially from solutions of strontium salts by precipitation with H_2SO_4 or soluble sulphates. A white precipitate, soluble in 7000 parts H_2O .

10. STRONTIUM SULPHIDE. SrS . Obtained by strongly heating SrSO_4 with C and extracting the melt. It is used chiefly for the preparation of other strontium compounds (acetate, chloride, carbonate, nitrate, hydrate).

11. STRONTIUM PEROXIDE, see No. 8 "STRONTIUM OXIDES".

12. STRONTIUM TARTRATE. $\text{SrC}_4\text{H}_4\text{O}_6$. Obtained by precipitating concentrated solutions of strontium salt with tartaric acid or ammonium tartrate.

Strontium compounds:

Willy Manger, Dresden, Germany.

Strophanthine. Two preparations obtained from *Strophanthus Kombe* and other species of *Strophanthus* are sold. The amorphous form is used medicinally. It is a strong poison acting on the heart. Its action is similar to that of digitaline.

Strychnine. $\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$. An alkaloid occurring in various plants. To prepare it the seeds of *Strychnos Nux vomica* (India and North-Australia) are used.

It is prepared by two distinct methods. The crushed nuts are moistened with H_2O until they swell, when they are ground to a slimy pulp which is extracted with hot alcohol; the alcohol is removed from the extract by distillation. The remaining aqueous extract is mixed with lead acetate solution in order to separate impurities, the excess of lead being removed by H_2S or H_2SO_4 . The alkaloids are precipitated from the purified solution by caustic soda. The strychnine is almost completely separated, while brucine (q. v.) also present with the alkaloids of the *Strychnos* species, remains dissolved as it is more readily soluble. According to the second method the seeds are boiled for 24 hours with water containing sulphuric acid. This boiling softens them completely. They are then pressed well and the alkaloids separated from the dark-brown clear liquid by excess of quicklime. The alkaloids are again extracted from the precipitate by boiling dilute alcohol after which the process is the same as above. Crude strychnine is freed from brucine by treating the dried mixture of alkaloids with concentrated alcohol which easily dissolves brucine without dissolving much strychnine.

The free strychnine base forms colourless anhydrous crystals, melting with decomposition at 260° .

Strychnine is a very powerful poison; it is used medicinally in the form of its salts.

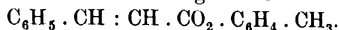
Stypticine. (*Cotarninum hydrochloricum*.) Cotarnine is formed when lukewarm nitric acid is allowed to act on narcotine; after the reaction the solution is filtered, the cotarnine in the filtrate precipitated by caustic potash, recrystallized several times, dissolved in the calculated amount of HCl and the solution evaporated in desiccators.

Yellow, crystalline powder, readily soluble in H_2O , prescribed internally and subcutaneously to stop bleeding.

Styptogan. An astyptic used externally. It consists of a paste of vaseline and permanganate.

Styptol. The cotarnine salt of phthalic acid. It is used medicinally like stypticine to stop bleeding.

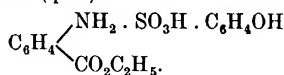
Styracol. The cinnamic acid ester of guaiacol



It is used medicinally as a tasteless and odourless substitute for guaiacol (q. v.). It decomposes into guaiacol and cinnamic acid in the intestines.

Styrax, see "STORAX".

Subentine = p-phenol-sulphonic-acid salt of paraamidobenzoic acid ethyl ester, i. e. of anaesthesin (q. v.).



Colourless and odourless fine crystalline needles M. P. 195.6°, sparingly soluble in H₂O. Said to be a good local anaesthetic.

Suberite. A substitute for cork, made according to a patented method of cork chips and an adhesive. In general it exhibits all the characteristics of natural cork, is entirely water-, weather-, and frost-proof, resists the action of boiling water and hot vapours, spirits, benzene, petroleum, carbon bisulphide, turpentine, HCl, &c. It is used as a substitute for bottle cork, bungs, &c., and as a polishing material.

Sublamine = mercury sulphate-ethylenediamine. HgSO₄ · 2 C₂H₈N₂ · 2 H₂O. A very powerful germicide. An excellent substitute for corrosive sublimate for disinfecting the hands and skin.

Sublimation. The process of sublimation is used for various purposes, e. g. purification of ammonium chloride (see "AMMONIA COMPOUNDS"), anthracene, benzoic acid and iodine.

Apparatus for subliming:

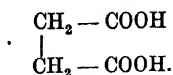
Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Substantive dyestuffs. These are dyestuffs which have sufficient affinity for the cotton fibre to render unnecessary the use of mordants. They are called direct or substantive cotton dyestuffs and are the alkali salts of aromatic sulphonic acids; usually they are disazodyestuffs (q. v.). To this group also belong the so-called sulphur dyestuffs.

On account of the ease with which they can be applied the employment of them is increasing.

The dyestuffs which in opposition to the above, require the assistance of mordants are less used and are called adjective dyestuffs. See "BASIC DYE STUFFS", "MORDANT DYE STUFFS", and "ACID DYE STUFFS".

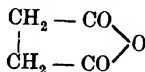
Succinic acid.



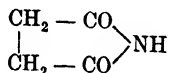
Is found in amber, in certain kinds of brown-coal and resins and in many animal and vegetable fluids.

It is usually obtained by the dry distillation of amber and evaporation of the aqueous distillate. The crystals, which are coloured by amber oil, are partially decolourized by animal charcoal. To remove completely all empyreumatic substances it is boiled with HNO_3 or recrystallized from chlorine water. According to ASCHAU (Intern. Congr. for Applied Chem. Berlin, 1903) succinic and adipic acids may be obtained from the naphthenes present in petroleum ether by oxidation with HNO_3 . The process has, so far, been of no practical importance.

When pure, succinic acid forms colourless monoclinic crystals. S. G. 1.552; M. P. 180° ; B. P. 235° . On boiling it is converted into the anhydride



100 parts water dissolve at 0° 2.88, at 100° 121 parts of the acid. The acid and its salts are used medicinally and in the preparation of coal-tar colours. By the action of NH_3 on the anhydride or by distilling ammonium succinate, succinimide



is obtained. The isomeric acid (methyl malonic acid) is of no technical importance.

Succinic acid:

C. Erdmann, Leipzig-Lindenau.

Succinimide see "SUCCINIC ACID".

Succinite see "AMBER".

Sucrol see "SWEETENING MATTERS, ARTIFICIAL".

Suction gas. It is a known fact that the so-called explosion motors, such as gas engines, benzine motors, petroleum motors, &c. make a proportionately better use of the energy generated than steam engines. This fact is most obvious in the case of gas motors.

The ordinary coal-gas motors, however, are hampered by being restricted to places where gas is laid on. For this reason efforts have for some time been directed to building explosion motors for generator gas, that is for gas which can be produced anywhere for individual use without difficulty. Compare "GENERATOR GAS". If the generator gas is for driving motors a compressed gas installation is fitted up with a steam boiler. In such a case a mixture of steam and air is blown by means of a steam current under pressure into the grating of the generator. At the very beginning of the operation the coal in the generator must be heated to a red heat. The gas generated passes off under pressure and after purification is conducted into the motor. The new suction gas plants now in use are much more convenient. The boiler is unnecessary and the vacuum caused by the expansion in the gas apparatus is filled by automatic suction with air drawn from the glowing layer of coals in the generator. More or less gas is produced, corresponding to the load of the machine. A further advantage is that a suction gas plant can be fixed almost anywhere, without risk or danger, as no gas can possibly escape from an apparatus made on the principle of vacuum suction on these lines.

An equipment for a suction gas plant consists of a generator, a water evaporator, an adjustable valve and the purifying apparatus. The generator is

provided with a valve. The generators are made of cast iron if the whole plant is on a small or medium sized scale; if larger they are of wrought iron. The generator itself consists of a shaft or cylindrical receptacle with fireproof sides, grating and fire-box, charging box and funnel. The charging box is fitted with an air-tight cover.

The hot gas passes from the generator into the evaporator (an open steam boiler where the heat is absorbed by the water). The steam thus produced mixes with the hot air formed during the preliminary heating and is then conducted under the grating of the generator hearth, where the steam and air mixture passing through the layer of glowing coals produce the motor gas, consisting of carbon monoxide, hydrogen, carbon dioxide and nitrogen. The gas after cooling in the evaporator passes through the adjustable valve into the purifier. This apparatus consists of a scrubber, or a scrubber and dry washer combined, or of both, and a shavings cleaner for catching furnace ashes, dust and so on. The simplicity or complexity of the purifying apparatus depends on the quality of the fuel employed and the kind, quality and variety of impurity to be removed. From this apparatus the gas passes direct into the motor. To start the machinery a ventilator (fan) and adjustable valve are provided. The ventilator serves for blowing air into the generator until inflammable gas is present. The adjustable valve serves to connect the gas escape pipe for carrying off the injurious or worthless vapours. The valve is made adjustable as it has to serve to connect the generator with the motor, or when the the motor is disconnected, with the waste gas pipe or chimney.

The ventilator can be worked by hand, electricity, by hydraulic pressure, or any other power that may be at hand, even if independent of and separated from the generator installation. The ventilator can also be fitted to work, at any rate for medium sized plants, by its own gas machine. In this case, however, the machine must be driven by coal gas or benzene while the generator is being fed by the steam and air current.

The installation must be supplied with a water connection for the evaporator, and to complete the equipment various utensils and pieces such as connecting parts for the different apparatus, valves, water vessels and so on must be provided. If the capacity and therefore the amount of gas generated varies to any great extent, this disadvantage can be done away with by adjusting a regulator to control the amount and quality.

If the gas is also to be used for heating or other purposes than driving the motor, an exhaustor must be provided for compressing the gas drawn off.

Sudoformal. 10 % formaline soap recommended for perspiring feet.

Sudol. A preparation recommended for perspiring feet. It contains formaldehyde and oil of wintergreen.

Sugar, kinds of. Compare "CARBOHYDRATES". Sugars are usually classed under two headings, grape sugars and cane sugars. The kinds belonging to the group of grape sugars (hexoses, glucoses, and monoses) have the formula $C_6H_{12}O_6$, while the members of the cane sugar group (bioses) have the formula $C_{12}H_{22}O_{11}$.

The hexoses have a sweet taste and are compounds which are as a rule crystalline and are readily soluble in water. They are however insoluble in ether and dissolve with difficulty in absolute alcohol.

Most of the members of this group can be fermented and are pentavalent aldehyde or ketone alcohols. To this sub-group belong grape sugar (dextrose, glucose) mannose, galactose, laevulose (fruit sugar) and many compounds produced by synthetic methods. *Starch sugar*, sometimes called potato

sugar, is not a pure grape sugar, as it contains *Dextrine* (q. v.) and other unfermentable substances.

To the group of cane sugars belong all those compounds having the constitution $C_{12}H_{22}O_{11}$, which are converted by the action of dilute acids with absorption of water into hexoses $C_6H_{12}O_6$. The compounds belonging to this group crystallize more readily and are more stable than those of the hexose group. As a rule they have a sweet taste and are readily soluble in water, &c. &c.

With the exception of maltose they do not directly ferment but only after previous decomposition into a hexose; they are optically active. The decomposition of the cane sugar group, which is caused by boiling with dilute mineral acids or by the action of enzymes, e. g. the diastase of malt, corresponds to the equation $C_{12}H_{22}O_{11} + H_2O = 2 C_6H_{12}O_6$. However, as a rule, two molecules of one hexose are not formed, but one of one kind and one of another. Cane sugar thus decomposes into glucose and fructose while milk sugar (lactose) separates into glucose and galactose; maltose alone forms two molecules of glucose. The mixture of glucose and fructose obtained by the inversion of cane sugar is called invert or inverted sugar, as it turns the plane of polarization to the left, while on the contrary cane sugar turns polarized light to the right. The most important members of the cane sugar group are, cane sugar or saccharose, milk sugar or lactose and malt sugar or maltose. Cane sugar is also sometimes called beet sugar, as it is not only made from the sugar cane, but also from the juice of the beet root. For particulars compare "INVERT SUGAR", "FRUIT SUGAR", "MILK SUGAR", "STARCH SUGAR", "SUGAR, MANUFACTURE OF", and "MOLASSES".

Sugar manufacture. (See "SUGARS".) The sugar manufactured in Germany is almost exclusively obtained from the juice of the sugar beet, i. e. the root of a cultivated variety of *Beta maritima*.

The beet roots are washed in washing machines; they are then cut up, not reduced to a pulp, but cut into long thin strips 0.5—1 mm in thickness (since the introduction of diffusion methods). This cutting is accomplished with cutting machines of various types.

The juice is actually obtained by the method of diffusion, based on the phenomenon of osmosis or membrane diffusion: When a sugar solution is present in a vessel formed of animal or vegetable membrane and the latter is placed in a vessel of water, the sugar molecules diffuse through the membrane into the water (exosmosis), while water molecules enter the inner vessel (endosmosis); this diffusion does not cease until the specific gravities of the two liquids inside and outside have become equal. Not only sugar, but all substances capable of crystallisation (crystalloids) are subject to diffusion, while non-crystallizing substances (colloids), like albumen, gum, pectine substances, &c. are hardly able to penetrate the membrane at all.

In the beet root the sugar juice is in separate cells of membrane, and when the strips (which on the whole may be regarded as sets of cells) are brought into contact with water, they are extracted by diffusion, i. e. the sugar passes into the water.

In order to obtain the sugar juice the cuttings are placed in several metal vessels, joined to a diffusion battery, and subjected to the action of warm water. The juice is tapped off. These diffusers are cylindrical and closed on all sides; they have a double bottom, an inlet tube high up and an outlet tube below, and are connected in a battery in such a way that the water enters vessel 1, the dilute sugar solution passing from there to vessel 2 and from this to No. 3 &c.; the juice leaving the last diffuser of the battery is fairly concentrated. When vessel 1 is exhausted it is cut off from the battery, filled with fresh cuttings and placed last in the series. The fresh water now enters 2, first charging itself with sugar, goes on to 3 &c., and finally from

12 into 1 when it leaves the battery. This circular process is carried on, so that each vessel in turn goes through all states of diffusion. When the juice passes from one vessel to another it is heated by indirect steam so that a temperature of 55–75° C is maintained throughout. A diffusion battery consists as a rule of 10–16 diffusers containing 3–12 cubic meters.

The cuttings are afterwards pressed and used as fodder (see "FEEDING STUFFS"); they should not contain more than 0.4 % sugar. About 100 liters of juice are derived from 100 kg of beet root.

A new method of obtaining the juice, STEFFEN'S *Scalding method* (Germ. Pat. 149593 and 153859) is the following: The beet root are cut into slices, scalded in water at 95° C and then pressed; about 70 % of the juice is thus obtained, the 30 % remaining being used as cattle food. The assertion that more sugar was obtained than by the diffusion process has been proved erroneous, so that this method cannot claim any practical importance; it is economically wrong to cultivate beet root containing much sugar and then to pass a part of it on to be used as cattle food.

According to Germ. Pat. 146871 sugar juice is obtained in a purer, more crystallizable state when formaldehyde is added to the diffusion water (0.0025% of the fresh slices).

The crude juice in addition to sugar contains salts, colouring matters, gelatinous matter and proteids, acids and other impurities which must be removed, as when these are present the sugar does not crystallize. The purification of the juice consists of *separation* and *saturation*, i. e. the hot juice is treated with slaked lime (*separation*) and the excess of CaO is removed with carbon dioxide and sulphurous acid (*saturation*). Formerly the custom was to separate with CaO first and then to saturate with CO₂, while at present the two processes are combined, followed by a subsequent saturation with SO₂.

The lime required is used as milk of lime; the process is carried out in separation or saturation pans, i. e. square, closed vessels of iron, the bottoms inclined strongly to the front. A steam coil is applied for heating purposes, while the carbon dioxide is conducted to the bottom whence it rises through numerous little openings; an outlet is provided to tap off the mash settling at the bottom.

In the process of separation the lime is converted into calcium saccharate, a compound which is very reactive. Organic acids are precipitated as insoluble lime salts; nitrogen compounds, like glutamine asparagine &c. are converted into ammonia and amido acids. The carbon dioxide entering at the same time precipitates the excess of lime as CaCO₃ and all these precipitates together form the mud.

Separation is effected by mixing the juice, which is warmed to 60° C and about half fills the pan, with milk of lime (2–3 kg fresh quick lime to 100 kg beet root) and then introducing carbon dioxide and steam, so that the temperature finally reaches 85–90° C. After the first saturation the juice should still be slightly alkaline. It is filtered, and now forms a clear light yellow liquid smelling of ammonia. The process is repeated once or twice and if the juice is not filtered through animal charcoal a subsequent saturation with sulphurous acid follows. More recently separation and saturation have been, to a certain extent, again carried out separately. Caustic lime and carbon dioxide are prepared in the factory itself by burning CaCO₃ in suitable furnaces from which the escaping CO₂ may be collected; the latter is purified and cooled by passing through water and is then forced into the saturation pans. The filtration of the juice in order to separate it from the mud is generally done in filter presses, more rarely through gravel, wood shavings, &c. Filtration through animal charcoal, used formerly to such a large extent, is now applied in refining only.

An exceedingly large number of other methods for purifying the crude juice has been recommended, all of which appear to be of little practical value.

Germ. Pat. 131875 recommends the addition of powdered manganese peroxide to the juice at about 60° C, together with 1.4 kg caustic lime. 50 g MnO_2 are added to each 100 kg of beet root and the mixture is then electrolyzed (5 volts 1 ampere per square metre electrode surface); the MnO_2 is intended to further the evolution of O at the anode and the oxidation of substances other than sugar.

Another proposal of this type is that of LEHMKUHL, in which small amounts of alumina are used while BERKEFELD applies 1 % sulphurous acid at 90° C. WERY recommends baryta with sulphurous acid, REMBERT barium aluminate, WAGNER phosphoric acid, &c., &c.

The purified dilute juice is now evaporated; there are two phases, the boiling down of the thin juice to a thick juice (about 50 saccharometer degrees) and that of thick juice to pulp, either a crystal pulp or supersaturated sugar solution containing more than 90 % dry substance.

The evaporation is carried out under reduced pressure (*in vacuo*) and below 100°; 2 or 3 vacuum apparatus are connected in such a way that the vapours from one are utilized in warming the next, the heating itself being effected by steam. When the thin juice is sufficiently evaporated it is passed from these boilers to another group where the evaporation of the thick juice is carried out. The thick juice finally obtained is filtered hot and further evaporated.

There are two methods of evaporation. In the first case the crystals are formed during boiling so that a stiff crystalline paste results; it is the method generally used, though it is applicable only for pure solutions containing not more than 20 % substances other than sugar. The other process produces a clear (supersaturated) solution which crystallizes on cooling. The evaporation is carried out *in vacuo*, the heating being by indirect steam. When a solution and not the crystalline paste is to be obtained the boiling is continued until a drop of the liquid forms a thread of a certain length between the fingers. The liquid, still completely clear, is run into large iron boxes where crystallization sets in.

When a crystalline paste is aimed at the process is initially the same. Later fresh thick juice is repeatedly added and evaporation continued, the pressure of the air being regulated in such a way that the juice is always at a temperature of 60—70°. At last the liquid is not able to keep all the sugar dissolved, and the formation of crystals sets in. It is possible to regulate the formation of the crystals, i. e. to produce a finer or coarser grain by adding the fresh juice more or less frequently and allowing the mixture to boil quietly or vigorously.

This substance, obtained by the one or the other process is let into large iron boxes. The liquid is set to crystallize in them while the crystallization already begun in the process of evaporation is completed. In either case the result is a thick mass of sugar crystals and syrup. The mass is crushed, mixed with additional syrup and centrifuged. By evaporating the syrup further and repeating the above process a product of second quality, and by a further repetition of the whole process a product of third quality are obtained.

The final residue is a viscous dark brown syrup of objectionable taste and smell, molasses, containing 45—50 % sugar. This sugar does not crystallize out as there is too much foreign matter present. For this reason the molasses were formerly used exclusively to produce spirits but now a method for separating the greater part of the sugar has been introduced. For the process of separating sugar from molasses see "MOLASSES".

The crude sugar thus obtained is of a yellow colour and has a taste and smell which is not agreeable. It is purified (refined) in special refining works, where the crude product is converted into white sugar which has no disagreeable smell or taste, and is ready for household use.

There are two methods of refining sugar. The first is that of covering, that is the crystals are covered with a pure sugar solution which gradually takes up the syrup clinging to the crystals. The sugar solution used is obtained by pouring water over the crude sugar of the first quality. Formerly the sugar solution was simply allowed to trickle through and the process repeated until the impure syrup had been removed and pure sugar solution run away. At present the same object is attained by centrifuges.

The second method of refining sugar consists of filtration through charcoal, a process which must be carried out very slowly and at high temperatures. Tall filtering cylinders are filled with animal charcoal and well heated by steam, then the syrup — a solution of crude sugar in water — is poured in from above. The concentrated juice coming out below is evaporated *in vacuo* until it crystallizes. The filtration must be carried out with fresh charcoal; since, when used several times, it becomes ineffective and must be "revivified". There are numerous methods of preparing the charcoal for future use (treatment with HCl, fermentation, &c.).

A preliminary purification has lately been introduced before filtration. The crude sugar is centrifuged, covered with sugar solution and then concentrated to a thick solution, which is clarified with lime, filtered through a filter press and then subjected to the above mentioned filtration through charcoal. In some cases the filtration through charcoal has become practically superfluous, since the filtration through filter presses has rendered it unnecessary.

When loaf sugar is required the syrup is boiled to the crystallizing point at the lowest possible temperature. The slightly yellow colour is concealed by adding a little blue dyestuff (50 g ultramarine to every 100 000 kg). When the mixture is evaporated to the point of crystallization it is run into pans and warmed to about 90° C so that the smaller crystals dissolve in the syrup. It is then poured into inverted iron cones and gradually allowed to solidify. An opening at the apex of the cone is then made so as to tap off the syrup. Sugar solutions of increasing degrees of purity are poured over the top (the base of the inverted cone) until all impurities are removed. Suction is finally applied to remove the last traces of moisture.

Sugar in lumps is obtained by centrifuging the coarse crystal mass and covering with pure sugar solutions. When no special shape is required the material is allowed to solidify in the centrifuges, otherwise it is pressed into plates and bars. The irregular lumps are obtained by breaking up the crystalline masses taken from the centrifuge, while lump sugar is prepared from the plates and bars by cutting in special cutting machines.

Sifted sugar is usually made from lumps and broken blocks by grinding them in mills and not infrequently by centrifuging the crystalline mass.

Crystal sugar is obtained by slow evaporating at a low temperature and under a low pressure, followed by centrifuging, covering and drying.

Sugar candy is obtained from the boiled liquid (not boiled to the crystallizing point) by allowing it to cool gradually in conical crystallizing vessels; the crystals grow on threads drawn through the vessels for this purpose. Beet sugar can only be used to make white crystals as the brown would exhibit a disagreeable taste due to the syrup. When brown crystals are desired the refined mass is dyed with caramel. Genuine brown crystals of agreeable taste can only be made from true cane sugar. S. G. of cane sugar solutions at + 15° C (SCHEIBLER):

%	S. G.	%	S. G.	%	S. G.	%	S. G.	%	S. G.	%	S. G.
0	1.00000	13	1.05293	26	1.11101	39	1.17470	52	1.24444	65	1.32067
1	1.00390	14	1.05721	27	1.11571	40	1.17985	53	1.25007	66	1.32682
2	1.00783	15	1.06152	28	1.12044	41	1.18503	54	1.25574	67	1.33301
3	1.01178	16	1.06586	29	1.12520	42	1.19024	55	1.26144	68	1.33923
4	1.01576	17	1.07023	30	1.12999	43	1.19550	56	1.26718	69	1.34550
5	1.01978	18	1.07464	31	1.13482	44	1.20079	57	1.27297	70	1.35182
6	1.02382	19	1.07907	32	1.13969	45	1.20611	58	1.27879	71	1.35817
7	1.02789	20	1.08354	33	1.14458	46	1.21147	59	1.28465	72	1.36457
8	1.03199	21	1.08804	34	1.14952	47	1.21687	60	1.29056	73	1.37101
9	1.03611	22	1.09257	35	1.15448	48	1.22231	61	1.29650	74	1.37749
10	1.04027	23	1.09713	36	1.15949	49	1.22779	62	1.30248	75	1.38401
11	1.04446	24	1.10173	37	1.16452	50	1.23330	63	1.30850		
12	1.04868	25	1.10635	38	1.16960	51	1.23585	64	1.31457		

For the manufacture of other kinds of sugar see "INVERT SUGAR", "MILK SUGAR", "STARCH SUGAR", "ALCOHOL".

Sugar manufacturing apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Vacuum-evaporation-apparatus for Sugar manufacture:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Manufacturing plants for milk Sugar:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Grape Sugar vacuum apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Sugar-testing apparatus:

Hans Heele, Berlin O. 27.

Sulphanilic acid. $C_6H_4(NH_2)SO_3H$. ($NH_2 : SO_3H = 1 : 4$.) This acid is obtained by treating aniline with H_2SO_4 at a high temperature. It is formed by decomposition of the aniline sulphate thus obtained. NEVILLE and WINTHER give the following process. 100 kg of pure aniline are mixed with constant stirring with 105 kg H_2SO_4 in an iron boiler lined with lead and fitted with a stirring apparatus. The melted mass is then spread on tins and heated in a furnace for 24 hours at a temperature of 200—250°. After cooling the grey sulphanilic acid is dissolved in H_2O and filtered. After purification by repeated recrystallization it forms colourless crystals which dissolve fairly readily in hot, but with difficulty in cold water. For making coal-tar colours, purification is usually unnecessary. The solution obtained directly from the melted mass by extraction is used for this purpose.

During the process of heating the aniline sulphate on tins (the so-called baking process) it is scarcely possible to avoid overheating. Hence the heating process is now often carried out in a vacuum.

TEST. On ignition, sulphanilic acid should leave no appreciable residue. The test for sulphuric acid is as follows. A solution of 1 g sulphanilic acid in 25 ccm boiling water is treated with a few drops of $BaCl_2$ solution. To prove the presence of hydrochloric acid 1 g sulphanilic acid is shaken with 20 ccm of water, filtered and the filtrate treated with $AgNO_3$ solution. At most a faint opalescence should be produced. To test for aniline 1 g of the acid is warmed with $NaOH$ solution and chloroform added; no smell of isonitrile should be observed.

To determine the amount of acid, 1 g is dissolved in 10 cc. $\frac{1}{10}$ N. NaOH and titrated with $\frac{1}{10}$ N. HCl. Each cc. of acid required = 0.20915 g of sulphanilic acid. If H_2SO_4 is present a weighed amount of the sulphanilic acid is moistened with BaCl_2 solution, heated on the water bath to expel HCl and then titrated as above described.

In case the crystals have effloresced the results obtained are too high.

Sulphine dyestuffs see "SULPHUR DYESTUFFS".

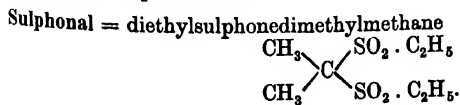
Sulphite cellulose see "CELLULOSE".

Sulphocyanide compounds (Thiocyanate compounds) are derived from sulphocyanic acid NCSH by simple addition by the action of S on metallic cyanides; or synthetically by heating carbon bisulphide with ammonia in autoclaves. The commercial sulphocyanides are always obtained from gas purification residues which contain from 0.8 to 4 % HSCN and more. Compare "COAL GAS". H_2S , NH_3 and CN are produced as by-products in the dry distillation of coal, and from these (either from the gas water or from the purification residue) (iron ore), the product called ammonium sulphocyanide or thiocyanate is formed. The purification substance after use, is systematically extracted with water and the lye (S. G. 1.070 to 1.085) is then evaporated to a strength of 22—24 Bé, when mixtures of $(\text{NH}_4)_2\text{SO}_4$ and NH_4Cl crystallize out. On further evaporation ammonium sulphocyanide is obtained containing 80—90 % NH_4CNS . As, however, a part of the salt is always decomposed during evaporation it is advisable to precipitate a weaker lye which may be impure, with CuSO_4 when the sulphocyanide separates quantitatively.

If lime is used for purifying the gas, the sulphocyanide is obtained in the form of calcium sulphocyanide. To obtain the latter salt in a pure state, the gas lime is leached and the solution obtained, containing calcium sulphocyanide and calcium thiosulphate, is evaporated. The sulphocyanide salts are said to remain unchanged while the thiosulphate decomposes into calcium sulphite and sulphur; both these substances are precipitated and may be used for the preparation of alkali thiosulphates.

According to Amer. Pat. 705152 coal gas is used for the preparation of sulphocyanides in the following manner. The gas which contains NH_3 and cyanogen compounds is successively washed in several scrubbers with H_2O or ammonia solution. The scrubbers must all contain S. From the first scrubber the strong ammonium sulphocyanide passes away from time to time, while the liquid is simultaneously transferred from one scrubber into the next. According to Engl. Pat. 8166 (1903) the cyanide compounds of coal gas are obtained in the form of magnesium sulphocyanide, by passing the gas, after removal of the tar and ammonia, through a liquid containing magnesium sulphide. This liquid is made by passing H_2S , or the gas from the lime purifier, through a mixture of magnesia and sulphur in H_2O and then pouring off or filtering from the product.

According to Engl. Pat. 24767 (1902) sulphocyanides are made from coal gas, which contains cyanogen, carbon bisulphide and ammonia by passing it through MgO or MgCO_3 , when the sulphocyanide is obtained as in the above-mentioned patent in the form of magnesium sulphocyanide. If the gas does not contain sufficient sulphur, more of this substance, or sulphides may be added to the liquid in which the magnesia is suspended. The same patent claims to obtain magnesium sulphocyanide by heating CS_2 and NH_3 with MgO in closed vessels at a temperature of 110° .



A mixture of acetone and mercaptan is condensed to mercaptol by the introduction of dry HCl-gas, the product then being oxidized to sulphonal by KMnO_4 .

A white, odourless, tasteless powder M. P. 125° , sparingly soluble in cold, a little more readily in hot H_2O , easily soluble in alcohol. It is a good narcotic.

Dose 1.0—1.5 g.

Sulphophosphite. The name given to a commercial substance which is important as an excellent substitute for yellow sulphur for the manufacture of matches. Sulphophosphite which consists of zinc, phosphorus and sulphur can be used in the manufacture of paraffin and sulphur matches. These may be prepared so as to ignite readily or otherwise. The mixing of the substance itself is without danger, as it is not necessary to grind the sulphophosphite with the KClO_3 . It is affected by the atmosphere to a less extent than red phosphorus and is considerably more stable than phosphorus sesquisulphide.

Sulphopyrine. A mixture of antipyrine and sulphanilic acid. Used in cases of headaches, &c.

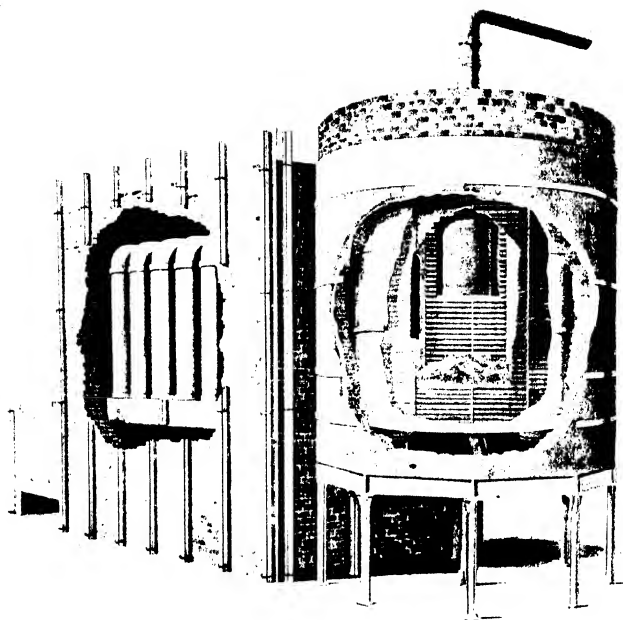
Sulphur. S. A. W. 32.06. The largest quantity is still derived from Sicily where pure sulphur is found in large deposits and veins; usually the sulphur is contaminated with sedimentary stones, and is obtained from the mixture simply by melting. The latter process was formerly carried out in kilns which were made of the sulphurous material, covered with clay, and then ignited; while nowadays the operation is performed in open cylindrical melting furnaces with a capacity of more than 1000 cubic metres, the hearth of which is strongly inclined towards the exit opening. The stone blocks are so arranged in the furnace that sufficient room for air channels is left between them; the roof is formed by a layer of already melted and powdered stone. When the S has been ignited the lower openings of the furnace are closed so that the combustion only proceeds very slowly from top to bottom. A part of the S burns to SO_2 and escapes; the principal amount collects in a molten state on the hearth and is run into wet wooden moulds, which yield blocks 50—60 kg in weight. Such a melting process lasts 30—90 days according to the amount of the stone. The GILL furnace works more economically in that the melting of the S of is performed by steam. By the use of this furnace the great injury suffered by the surrounding vegetation through the SO_2 is almost completely avoided.

If the natural sulphur occurs almost free from stone and earthy impurities it is melted directly in cast iron boilers.

The method of obtaining sulphur in Texas and Louisiana—where the sulphur is found at a depth of 150—200 metres in large deposits of gypsum—is highly interesting. Several tubes one inside the other are driven from the surface down into the sulphur stone, and then superheated H_2O at 165° is forced down into the tube, and the sulphur in this way melted. In order to force the sulphur to the top more readily air under a pressure of 20 atmospheres is also pressed through a narrow tube down to the bottom. The bubbles of air mix with the melted sulphur and so diminish the S. G.; the mixture then ascends in a quick stream to the top. The boreholes give a daily yield of 200 tons or more of sulphur.

Further S is also obtained by heating iron pyrites FeS_2 in the absence of air. In this process ($3\text{FeS}_2 = \text{Fe}_3\text{S}_4 + \text{S}_2$) only one third of the S of the pyrites is obtained. Very often the process is modified so that FeS_2 is ignited in blast furnaces: about half of the S burns to SO_2 , while the other part sublimes and is collected in wooden chambers.

According to Germ. Pat. 134734 sulphur can be obtained from sulphur ores and sulphides by the electrolysis of the fused mass—the sulphur ore



DEACON CHLORINE PROCESS: SUPERHEATER AND DECOMPOSER



WORKER: REIDERS

(e. g. galena) together with a bath made from the difficultly fusible chlorides of a heavy metal (e. g. PbCl_2) being heated to a high temperature and then subjected to electrolysis. Here the metallic chloride, which serves as a bath, decomposes into metal and chlorine; the latter then acts on the ore in such a way that it unites with the metals again to form chlorides, while S is liberated and can be condensed. The following equations express the reaction for galena: 1. $\text{PbCl}_2 = \text{Pb} + \text{Cl}_2$ and 2. $\text{PbS} + \text{Cl}_2 = \text{PbCl}_2 + \text{S}$. The metal separates out at the cathode, while the chlorine liberated at the anode decomposes the ore.

Further experiments have also been made with a view to obtaining S from the gas purifying masses which become rich in S (see "COAL GAS") — they contain more than 40 % S; but the results obtained by distillation with superheated steam and by extraction with CS_2 have not been very satisfactory.

The different proposals however for obtaining S from the waste products of the LE BLANC process (see "SODIUM CARBONATE") appear to be more important. Of the numerous processes may be mentioned two, namely, 1. that of SCHAFFNER and HELBIG and 2. that of CHANCE; these are probably the only ones which can lay claim to great practical importance. SCHAFFNER and HELBIG allow the alkali waste to enter gradually through a spiral into a strong solution of magnesium chloride (above 24°Bé) contained in a closed iron cylinder provided with stirring contrivances. The calcium sulphide is here decomposed by the MgCl_2 as shown in the equation $\text{CaS} + \text{MgCl}_2 + \text{H}_2\text{O} = \text{CaCl}_2 + \text{MgO} + \text{H}_2\text{S}$. The H_2S meets with SO_2 in a tower, down which calcium chloride solution simultaneously trickles. The presence of the latter has been found necessary in order to render the precipitation of the S complete according to the equation $2 \text{H}_2\text{S} + \text{SO}_2 = 2 \text{H}_2\text{O} + 3 \text{S}$, and at the same time to give the S a granular structure so that it can be filtered. After the reaction the contents of the iron cylinder are poured out through a sieve which keeps back the coarser parts of the alkali waste, while the MgO , which is precipitated in the fine state, is treated together with CaCl_2 in other vessels with CO_2 . Here the following reaction $\text{MgO} + \text{CaCl}_2 + \text{CO}_2 = \text{CaCO}_3 + \text{MgCl}_2$ takes place, that is, the MgCl_2 is regenerated, and can be used again for the decomposition of more alkali waste.

CHANCE's process, which is widely used, consists in treating the sieved alkali waste with CO_2 (that is, with gases from lime furnaces containing a high percentage of CO_2) in cylinders united together in series; the CaS is first converted into calcium sulphhydrate $\text{Ca}(\text{SH})_2$, which then decomposes with evolution of H_2S : $2 \text{CaS} + 2 \text{H}_2\text{O} + 2 \text{CO}_2 = 2 \text{CaCO}_3 + 2 \text{H}_2\text{S}$. The furnace gases must be free from O as otherwise S would be lost by oxidation. The H_2S is caught in large gasometers over oil of tar, and then mixed with an exact amount of air (corresponding to the equation $2 \text{H}_2\text{S} + \text{O}_2 = 2 \text{H}_2\text{O} + \text{S}_2$), and led under the grate of a blast furnace in which is a layer of iron oxide heated to a dark red heat. The latter only needs to be heated once to a red heat before the beginning of the process; afterwards it is kept in this state by the heat of reaction and brings about the complete combustion of the H_2S to H_2O and S. The sulphur fumes are condensed in chambers. The most difficult point of the process is that the gas caught in the gasometer must always contain the same amount of H_2S , otherwise the air admitted contains either too much or too little O; in the first case a part of the S is converted into SO_2 , and in the second a part of the H_2S escapes unchanged.

The crude sulphur, however obtained, is purified by sublimation. The condensation chambers soon become heated above the melting point of the sulphur, which causes the latter to collect in a melted state on the floor; it is then allowed to flow into moulds. The stick sulphur thus obtained is almost chemically pure. If the sublimation takes place slowly, so that the condensing chambers do not reach a higher temperature than 110° , the sulphur is obtained

in the form of flowers of sulphur, a loose snow-like pale yellow mass, which is always impure through traces of SO_2 or H_2SO_4 .

In nature sulphur occurs in rhombic crystals, while on cooling from the melted state it crystallizes in the monoclinic system. It is bright yellow, and can be readily powdered, S. G. 1.98—2.06; M. P. 111—114.5° (the data differ somewhat). Sulphur, which forms a thin yellow liquid at its melting point, on being heated to 160° becomes thick and orange yellow, at 220° it becomes viscous and reddish, between 240° and 260° it is very viscous and reddish brown, above 340° it is reddish brown but a little more mobile; it boils at 444.5°, at which temperature dark brown yellow fumes pass over. Sulphur heated to 230° and then suddenly cooled by pouring into water becomes soft and plastic so that it can be used for mouldings; after a few days it becomes quite hard again. At 250° sulphur ignites in the air and burns with a blue flame forming SO_2 . It is insoluble in H_2O , very sparingly soluble in alcohol and ether, more readily soluble in hydrocarbons, readily soluble in chloroform, sulphur chloride, and above all in carbon disulphide. 100 parts CS_2 dissolve at 15°, 37.15 parts at 47°, 146.21 parts S. On being boiled with HNO_3 , aqua regia, NaOH , KOH , and alkali sulphides it also goes into solution, in that it combines with these agents or is oxidized by them. It is a non-conductor of electricity.

The most important use of S is for the manufacture of H_2SO_4 ; it is also used for the preparation of SO_2 , sulphites, thiosulphates, CS_2 , gun powder, matches, cinnabar and other metallic sulphides, ultramarine, for vulcanizing caoutchouc and guttapercha, for bleaching silk and straw, for sulphuring hops, and wine barrels, as a remedy for diseases of the vine, for making putty, &c.

TEST. The testing of crude sulphur is usually restricted to the estimation of ash, arsenic, and occasionally also the moisture. The amount of ash is found by burning 10 g S in a porcelain crucible. For the estimation of the moisture a good average sample of at least 100 g must be taken. The qualitative test for arsenic is advantageously carried out according to HAGER's Kramato method (Pharm. Centralbl. 1884, 265 and 443): 1 g S is shaken with 15 drops of NH_3 and 2 ccm H_2O , after half an hour brought on to a filter, and the filtrate treated in a test tube with 30 drops HCl and 15 drops of oxalic acid solution. Then a clean piece of brass sheet is placed in the tube and heated to 60—100°, when an iron-coloured or black coating is immediately formed on the brass strip if As is present. SCHAPPIO's method for the quantitative estimation can be recommended: according to this method the sulphide and oxide of arsenic are extracted from the S by digestion with dilute NH_3 at 70—80°, the ammoniacal solution, exactly neutralized with NH_3 , diluted, and titrated with $\frac{1}{10}\text{N}$ -silver solution; as an indicator neutral potassium chromate may be used, which, as soon as the As is precipitated, is turned brown by a drop of the solution. The arsenites are found in the residue after the extraction of S with CS_2 ; the residue is digested with aqua regia and As tested for in the ordinary way.

The presence of Se is shown as follows: S is oxidized by heating with KNO_3 , dissolving the fused mass in HCl , and treating with SO_2 ; Se is here precipitated as a red powder.

At the V. Intern. Congress for Applied Chem., Berlin 1903, v. KONECK recommended a new and simple process for the quantitative estimation of S in coal, petroleum, asphalts, and organic compounds in general. This method, to which the lecturer applies the name "Rapid" on account of its being so quickly and readily carried out, depends on the oxidation of the substance in the PAAR's calorimeter with Na_2O_2 , and the estimation of S as H_2SO_4 with BaCl_2 . The oxidation product is brought into a beaker with H_2O , care being exercised as the O from the Na_2O_2 gives small explosions with traces of carbon left behind and thus easily causes splashes. The method yields very satisfactory results with raw oils, bitumen, coal, and asphalt; the S is also completely

oxidized even when C particles remain behind. A simultaneous estimation of the halogens is not possible as they become partly oxidized by Na_2O_2 .

Sulphur dyes (Sulphine colours). A large class of tar dyes, the constitution of which has not as yet been exactly determined. The majority of sulphur colours are obtained by the sulphur-sodium sulphide fusion, that is, by heating sulphur and alkali sulphides with sawdust, different para-diamines, acetylnitramines, quinone, &c. Thus the oldest sulphur dye, Cachou de Laval, is obtained by fusing sawdust with sodium sulphide, Vidal black by fusing p-amidophenol with sulphur and sodium sulphide, &c. Not only numerous benzene derivatives but also naphthalene compounds, &c. have been subjected to the sulphur-sodium sulphide fusion; the derivatives of diphenylamine prove to be the most important starting points for the sulphine colours. Thus the excellent fast Immedial black is obtained by fusing p-oxy-o-p-dinitro-diphenylamine with S and Na_2S . On the other hand it is the m-diamines of the benzene series, principally m-toluylenediamine, from which the sulphur colours are prepared.

The number of the new sulphine dyes can now hardly be estimated, and their uses are becoming wider and wider. Recently efforts have been made to use, from the beginning, substances containing sulphur — even partly prepared dyes (e.g. thiazine derivatives) — as the starting points for the manufacture of sulphur dyes, in order to give such substances, which in themselves are of little value, the excellent properties of the sulphine colours.

Gradually the technically valuable diphenylamine derivatives have become (as far as the production of sulphine colours is concerned) exhausted, and attention is now turned to other starting materials. Thus numerous processes have been patented which first prepare indophenols, and then fuse or boil these with S and Na_2S to give sulphine dyes. As far as these indophenol-sulphur dyes are concerned the French Pat. 330388 and 332884 seem to be destined to become important. See "INDOPHENOLS".

It may be mentioned that there is a tendency to improve the common sulphur fusion, as it has been found that high temperatures $150-200^\circ$ readily cause the formation of objectionable secondary products. Thus in the latest sulphur dye patents temperatures of only 100° are frequently given; the reaction is carried out in aqueous or alcoholic solution. In general more attention is now being paid to keeping within certain temperatures, since it has been found that frequently differences of temperature of $30-50^\circ$ completely alter the final product.

Other processes aim at preparing sulphur dyes which are less strongly hygroscopic than these products usually are (the hygroscopic nature is due to the amount of sodium sulphide). Mention may be here made of Germ. Pat. 144104, according to which a mixture of thiosulphate and caustic alkali is used instead of S and Na_2S .

The sulphur dyes are all substantive, that is, they dye cotton without mordants. The dyeing is carried out in a hot Na_2S bath with the addition of NaCl or Na_2SO_4 . The dyes are dissolved by the excess of Na_2S in the dye-bath, reduced to a leuco compound, and absorbed as such by the cotton fibre; the leuco compound is again oxidized in the air to the dyestuff. The dyes thus obtained are as a rule fast; at times the depth of the colour and the fastness may be improved by an oxidizing after-treatment, e.g. with $\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4$.

French Pat. 319876, which deals with a process for the direct production of sulphur dyes on the fibre, is very interesting. The cloth is soaked in a mixture of sodium tetrasulphide and p-amidophenol, and then steamed under pressure, when a blue black is developed.

Up to the present only black, blue, violet, green, and brown sulphur colours have been discovered; of these the black and dark blue dyes have become

of the greatest importance for cotton dyeing on account of the property of being fixed on cotton without mordant, on account of their great fastness to light and washing, and finally on account of the comparatively low price.

Attempts to prepare a red dye of this class have been successful. An azo-dye containing S is prepared according to French Pat. 337329 as follows: Dinitrochlorbenzene is heated with KCNS in alcoholic solution until the Cl has been replaced by the group CNS. It is then reduced with ammonium sulphide, the resulting nitroamidothiophenyl derivative is diazotized, and finally combined with corresponding azo components, according to the choice of which orange-red to pure red colours may be obtained. If for instance naphthylamine be employed a red dye is obtained. The dyeings on cotton with this material become very fast by oxidation or by treatment with metallic salts.

Sulphuretted hydrogen. H_2S . Hydrogen sulphide. This substance is produced from FeS (obtained by placing a well mixed quantity of 30 parts of iron filings and 21 parts of flowers of sulphur in a red hot earthenware crucible.) In practice the sulphide of iron is obtained by heating pyrites, FeS_2 , in a vacuum, or by melting iron pyrites with copper slag, whereby the superfluous S of the FeS_2 passes to the Fe contained in the copper slag.

The FeS in pieces the size of a nut is decomposed with diluted mineral acids, preferably with diluted H_2SO_4 , 1 : 3 to 1 : 4, whereon the reaction corresponding to the equation $\text{FeS} + \text{H}_2\text{SO}_4 = \text{FeSO}_4 + \text{H}_2\text{S}$ follows. The purest H_2S is obtained by the decomposition of grey antimony ore, Sb_2S_3 , with concentrated H_2SO_4 , or from pure BaS . The latter substance decomposes, as is the case with FeS , with diluted acids at an ordinary temperature.

According to Amer. Pat. 718556 pure sulphuretted hydrogen is obtained from the SO_2 contained in furnace gases or in other gas mixtures, in the following way. The SO_2 is absorbed in strong sodium sulphite solution, the SO_2 absorbed is combined with Ba by letting the sodium bisulphite act upon BaCO_3 , and catching the pure CO_2 evolved.

The barium sulphite thus produced is reduced by heating to a red heat with coal to BaS , which is then made to react with CO_2 forming H_2S with reproduction of BaCO_3 . H_2S is a colourless and very poisonous gas with a most unpleasant smell. The S. G. is 1.178, air being equal to 1. At $\frac{1}{4}$ - 10° it can be compressed at 15 atm. to a liquid, which has a S. G. of 0.9, with $\text{H}_2\text{O} = 1$. The boiling point is -74° , at 760 mm pressure, and the solidifying point is -85° . 1 vol. of H_2O dissolves 4.3 vol. at 0° , at 15° 3.2 vol. of H_2S gas. The saturated solution is known under the name of sulphuretted hydrogen water.

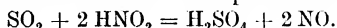
Sulphuric acid. H_2SO_4 . The materials for the manufacture of H_2SO_4 are SO_2 , KNO_3 , O and H_2O . The SO_2 is now but seldom made by burning sulphur; sometimes it is still obtained by roasting the residues obtained in purifying coal gas, see "SULPHUR". Generally, however, it is prepared by roasting ores, of which iron pyrites is the one most frequently used. Copper pyrites, zinc blende and galena are also used. The greatest care must be taken so that the gases which come from the furnace contain the highest possible percentage of SO_2 and that they contain also sufficient O for economical production. The numerous details of construction of the different furnaces cannot be here discussed. The roasting is carried further if the main object be to obtain gases for the manufacture of H_2SO_4 than in the case when they are obtained as a by-product in some metallurgical process.

In the former case the roasting must be as complete as possible in accordance with the following equation $2\text{FeS}_2 + 11\text{O} = \text{Fe}_2\text{O}_3 + 4\text{SO}_2$.

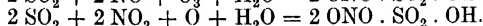
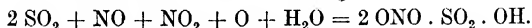
The SO_2 mixed with the proper quantity of air enters the lead chambers, after having been cooled in cast iron cooling tubes to $60-90^\circ$ and freed from as much dust as possible by passing through smoke chambers.

The cooling, which is usually effected by allowing the heat from the gases to cause evaporation of dilute H_2SO_4 is unnecessary if a GLOVER tower is present. The lead chambers consist of leaden plates soldered together and fastened into a wooden frame. Only the top and sides are of leaden plates so that the bottom part which is left open hangs in a shallow basin. The closing of the vessel is effected by the acid at the bottom into which the side walls of the chamber dip. At least two to three lead chambers are fitted together to form a system, each chamber with a capacity of 1000—3000 cbm. For every 1 kg of FeS_2 which is roasted in 24 hours about 0.5 cbm chamber space is necessary. Each chamber, with the exception of the last which serves as a drying chamber, is fitted up so as to allow of the entrance of the steam necessary for the reaction (to 1 kg S about 2.5 kg H_2O). Quite lately, however, it has been found that it is much better to use a very fine water spray instead of steam. This method is protected by the French Pat. 342117.

The oxidation of SO_2 to H_2SO_4 is carried out by means of nitrous fumes, that is the higher oxides of nitrogen and more especially, nitrous acid, HNO_2 . Formerly the process was believed to correspond to the equation,



According to this view the excess of atmospheric oxygen present immediately converts the NO into nitrous acid again, or at any rate into its constituent gases. $2 \text{NO} + \text{O} + \text{H}_2\text{O} = 2 \text{HNO}_2$. Instead of the HNO_2 the anhydride N_2O_3 can be effective, or in place of this again, the products of its decomposition $\text{NO} + \text{NO}_2$. Of late, however, the opinion has been formed that the reactions which takes place in the lead chambers are more complicated. According to LUNGE, nitrosyl sulphuric acid, nitrosulphuric acid, HSNO_5 is first formed. The most important reactions leading to the formation of nitrosyl sulphuric acid in the lead chambers are the following:—



Of these reactions, according to the above authority, the first named is dominant in the greater part of the chamber system. The second appears at first when there is excess of nitric oxide and oxygen. The third comes into consideration in the last division of the chamber when N_2O_4 is present in excess. On coming into contact with excess of H_2O , the nitrosyl sulphuric acid is at once converted into H_2SO_4 . $2 \text{HSNO}_5 + 2 \text{H}_2\text{O} = 2 \text{H}_2\text{SO}_4 + \text{HNO}_3$. The nitrous acid now present, which may be considered either as a hydrate or as an anhydride, now forms, (from fresh amounts of SO_2 , air and H_2O), H_2SO_4 again, so that theoretically this one supply of nitrous fumes is sufficient for a sulphuric acid factory. Practically, of course, losses of nitrous acid occur which amount to about 1—2 % of the amount of H_2SO_4 manufactured.

For the oxidation of the nitrous vapour, the lead chambers have of late been worked with mechanical air intakes in the form of stone ventilators (fans). Since the gases from the ovens do not consist of SO_2 and O only but contain much N, the latter must be allowed to escape and in escaping these carry off a considerable amount of the nitrous fumes. To prevent this loss and the nuisance which such gases would be to the neighbourhood the gases at a temperature of about 40°C are allowed to pass upwards through a GAY-LUSSAC tower. This is a tower lined with leaden plates and filled with coke down which 80 % H_2SO_4 trickles. With proper regulation in the GAY-LUSSAC tower the nitrous fumes, $\text{NO} + \text{NO}_2$,

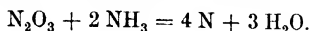
from the H_2SO_4 will be completely absorbed with formation of nitrosyl sulphuric acid $2 \text{H}_2\text{SO}_4 + \text{NO} + \text{NO}_2 = 2 \text{HSNO}_3 + \text{H}_2\text{O}$. From the H_2SO_4 containing nitrosyl sulphuric acid which is collected at the bottom, the HNO_3 is regenerated and again allowed to pass into the chambers. This regeneration (*denitration*) takes place in the above mentioned GLOVER tower. Such a tower is now found in all sulphuric acid works of any size. It serves three purposes. Besides regenerating the nitrous acids of the GAY-LUSSAC tower it has to cool the furnace gases which are at a temperature from 50° to 80° (average 60°), and it finally serves to concentrate the so-called chamber acids, the H_2SO_4 issuing from the lead chambers from 50 — 55° Bé to 60 — 62° Bé. The GLOVER tower is about 3 m in diameter and 10 m high. It consists of an outside frame of cast iron lined with lead plates, which again are covered on the inside with acid proof stones, or (in a newer process now much in use) with plates of lava. The tower is filled with flints and the nitrous contents of the GAY-LUSSAC tower as well as the chamber acid are pumped up and the mixture allowed to trickle, through suitable partitions, over the flints. Simultaneously the hot furnace gases of the pyrites ovens at a temperature of 200 — 400° (average 300°) ascend the tower, where they are first denitrated and then concentrated to 80 % (about 61° Bé). A higher degree of concentration should not be attempted as otherwise the material of the GLOVER tower is quickly destroyed. The denitration of the nitrous gases takes place in accordance with the equation, $2 \text{HSNO}_3 + \text{SO}_2 + 2 \text{H}_2\text{O} = 3 \text{H}_2\text{SO}_4 + 2 \text{NO}$. It can therefore be seen, that apart from the denitration, H_2SO_4 is actually formed in the GLOVER tower, before the gases reach the lead chambers. The reason for concentrating the chamber acids in the GLOVER tower at the same time is because otherwise loss of nitre would occur through secondary reactions, while, as it is, the nitrous gases are also partly denitrated through the dilution with the chamber acids. The furnace gases, which enter the lead chambers from the GLOVER tower at about 60°C gradually lose their SO_2 while passing through the chambers, while the concentration of the regenerated NO_2 increases as it approaches the end chamber. The gases should be of a deep red colour on leaving the chambers and entering the GAY-LUSSAC tower, and should still contain a certain quantity of O.

Some of the 80 % H_2SO_4 issuing from the GLOVER tower is pumped into the GAY-LUSSAC tower, see above, for the purpose of absorbing the nitrous gases, while the greater part of the acid can be directly used for many technical purposes, e. g. the preparation of salt-cake in the LEBLANC soda process. For conveying the acids to the tops of the two towers, cast iron or earthenware pumps, and cast iron or lead pipes are used. The lifting is performed by compressed air. Either the nitrous vapours from outside are conducted into the chambers for the oxidation or the nitric acid present, which is reduced in the chambers to HNO_2 , or SO_2 is employed for this purpose. In the former case, the gases are obtained by decomposing sodium nitrate with H_2SO_4 in special nitre ovens. These ovens or furnaces however are now seldom used in Europe. Formerly they were not heated in any special way, but only by the furnace gases, coming from the pyrites ovens, which passed through a brick-work flue in the nitre oven and there played round the pans in which the decomposition of the NaNO_3 took place. In this case, of course, the furnace gases entered the GLOVER tower after having passed the nitre.

When the H_2SO_4 is not to be used in the crude state or at the strength at which it leaves the GLOVER tower, it is purified from the many impurities, more especially from As and N_2O_3 . The minor impurities separate of their own accord. To precipitate the As, H_2S is developed from $\text{FeS} + \text{H}_2\text{SO}_4$ and conducted into an arsenic precipitating tower in contact with H_2SO_4 . Not only the As but other metals which can be precipitated from acid solutions, as well as the selenium will then be precipitated, but the H_2SO_4 for this purpose

must be diluted to 46—50° Bé as H_2S is decomposed by the concentrated acid with separation of S.

The removal of oxides of nitrogen is carried out by adding ammonium sulphate to the H_2SO_4 in the evaporating pans, when the nitrogen compounds decompose with evolution of nitrogen as follows:—



Should the concentration attained in the GLOVER tower (61—62° Bé) not be sufficient, the H_2SO_4 can be further concentrated in cast iron vessels. In this case however great care must be taken that the cast iron does not come into contact with acid having a concentration less than 60° Bé. The H_2SO_4 purified by H_2S , that is H_2SO_4 diluted to 46—50° Bé is almost always evaporated in two stages, first to 60° Bé and then further to 66° Bé. The concentration to 60° Bé is almost always done in lead pans, either fired from below, or heated with steam. For the second concentration to 65° Bé, glass retorts, glass dishes, or, according to the most modern methods, porcelain basins are used, these being heated on sand baths. Recently a new material has been introduced called *neutral iron*, which is highly resistant to H_2SO_4 and HNO_3 , and is said to be well adapted for the construction of vessels for concentrating sulphuric acid.

Generally apparatus of platinum is used for acid above 60° Bé. From 65° Bé upwards, this metal is absolutely essential. There are three main systems:—

1. FAURE and KESSLER's system,
2. DEPLACE's system, and
3. PRENTICE's system.

Of these, that of KESSLER is the most generally employed. The platinum apparatus is now almost always lined with gold, after the manner introduced by HERAEUS, which considerably increases their durability.

If the sulphuric acid works have no GLOVER tower, the weak chamber acids are at once concentrated in leaden pans, the heat being from above. In this way it is true the acid obtained is darkened by the smoke but it is none the less very suitable for many purposes, for instance for the manufacture of sulphates, superphosphates, &c.

Of late a new method protected by the Germ. Pat. 134661, and invented by Dr. ZANNER has become widely used. In the ZANNER concentration process a new plan is adopted, viz. that of building pans directly into the furnace flues, which is very simple and saves the cost of heating. These pans are made of special cast iron and are fitted throughout with acid-proof earthenware plates, which again on their part are strengthened by perforated cross supports. As a protection from soot the pans are covered, and the cover for drawing off the gas is arranged with openings protected by safety caps so that no smoke or dust can enter.

Instead of the GAY-LUSSAC towers, the smaller, and more effective reaction towers, such as the LUNGE-ROHRMANN plate towers, the ball tower, the GUTTMANN ball tower and other similar constructions are used. Compare "REACTION TOWERS". The same towers can also replace the lead chambers themselves, that is they play a distinct part themselves in generating the H_2SO_4 , the only exception being the first named, the LUNGE-ROHRMANN apparatus. For this reason the above towers are called assistant towers.

The GLOVER tower is also now often filled with earthenware cones, basins, pipes, &c. instead of with flints.

A large portion of the H_2SO_4 is used in the preparation of saltcake Na_2SO_4 , an intermediate product in the manufacture of Na_2CO_3 . Since the CaS of the alkali waste has been made available through the comparatively recent introduction of CHANCE's process it may be pretty safely prophesied

that pyrites will be more and more replaced by alkali waste in the manufacture of H_2SO_4 ; see "SULPHUR". For by this process the H_2S obtained from CaS is burnt to SO_2 and steam. The heat is sufficient to work the GLOVER tower and at the same time to concentrate the acids in the lead evaporating pans, which are placed on the furnace. After their passage through the GLOVER tower the gases derived from the burning of the H_2S are conducted into the lead chambers where they are converted, almost quantitatively, into H_2SO_4 . The sulphuric acid thus obtained is almost pure, there being no As or Fe present.

The new anhydride process is of the greatest importance and is now carried out in numerous ways. Concerning this method see "SULPHURIC ACID ANHYDRIDE". By simply dissolving the latter in H_2O pure H_2SO_4 of any concentration can be obtained, or SO_3 vapour can be passed into 50 % H_2SO_4 whereby acid of any desired strength, containing any percentage of anhydride can be prepared. When the anhydride process was discovered it was prophesied generally that it would gradually replace the complicated and clumsy lead-chamber method. It seems however that for cases where the object is the preparation of weak or not very pure acid the older, and well tested process continues and will continue to hold its own against the new comer, which after all is not, as yet, so well proven, is more difficult to manage and is restricted by the fact that it can only be worked under a licence. This explains why lead-chamber works are still being built. It is said that the MEYER tangential chamber system (Germ. Pat. 101376, also Germ. Pat. 186164) which uses round chambers in conjunction with reaction towers and ventilators offers many advantages, and is increasing in favour. In addition to the anhydride method, there is another process for the preparation of pure H_2SO_4 . This consists in cooling moderately pure 98 % acid to -10° when the monohydrate H_2SO_4 separates. By recrystallization a much purer product is obtained. Absolutely chemically pure H_2SO_4 is obtained by the fractional distillation of technically pure acid, but the latter must on no account contain any volatile compounds, more particularly As and HF.

The experiments for preparing H_2SO_4 by the electrolytic oxidation of SO_2 seem not to have attained any industrial importance. The Germ. Pat. 127985 protects a process for electrolysing dilute sulphuric acid. A diaphragm is used between the liquid and gas chambers, and SO_2 is passed into the anode compartment. The SO_2 is there oxidized quantitatively to sulphuric acid while simultaneously pure hydrogen in equivalent amount is formed at the cathode. Another process (Germ. Pat. 117129) also deals with the electrolytic conversion of SO_2 into H_2SO_4 and gives the same result as the above-named patent, by adding manganese sulphate as an oxidizing agent to the sulphuric acid in the anode compartment. In this way, it is said a sulphuric acid of 63.6° Bé is obtained from SO_2 . For the present however it seems doubtful whether an electrolytical sulphuric acid process can hold its own for practical and economical purposes.

Finally processes for obtaining H_2SO_4 and HCl by means of Cl and SO_2 simultaneously have been described. Of these processes there may be mentioned those described in Germ. Pat. 157043 and 157044. According to these the gases from pyrites furnaces and Cl are conducted from below into a reaction tower filled with stones, while from above only sufficient H_2O flows as is necessary for the formation of concentrated H_2SO_4 and gaseous HCl . For further details see patent specification. The patents will probably prove of no great importance in sulphuric acid manufacture.

See also "SULPHURIC ANHYDRIDE", "FUMING SULPHURIC ACID", and "PER-SULPHURIC ACID".

Pure concentrated H_2SO_4 is a colourless odourless fluid. It is oily and highly corrosive. S. G. 1.842 at 12° , B. P. 338° . It contains about 1.5 % H_2O .

SULPHURIC ACID.

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Specific Gravity 15° at 4° (in vacuo)	Degrées Baumé	Degrées Twaddell	100 parts by weight contain (as pure acid)				1 liter contains (reckoned as chemically pure acid)			
			SO ₂ %	H ₂ SO ₄ %	60° acid %	50° acid %	Kilo SO ₂	Kilo H ₂ SO ₄	Kilo 60° acid	Kilo 50° acid
1.000	0	0	0.07	0.09	0.12	0.14	0.001	0.001	0.001	0.001
1.005	0.7	1	0.68	0.83	1.06	1.33	0.007	0.008	0.011	0.013
1.010	1.4	2	1.28	1.57	2.01	2.51	0.013	0.016	0.020	0.025
1.015	2.1	3	1.88	2.30	2.95	3.68	0.019	0.023	0.030	0.037
1.020	2.7	4	2.47	3.03	3.88	4.85	0.025	0.031	0.040	0.050
1.025	3.4	5	3.07	3.76	4.82	6.02	0.032	0.039	0.049	0.062
1.030	4.1	6	3.67	4.49	5.78	7.18	0.038	0.046	0.059	0.074
1.035	4.7	7	4.27	5.23	6.73	8.37	0.044	0.054	0.070	0.087
1.040	5.4	8	4.87	5.96	7.64	9.54	0.051	0.062	0.079	0.099
1.045	6.0	9	5.45	6.67	8.55	10.67	0.057	0.071	0.089	0.112
1.050	6.7	10	6.02	7.37	9.44	11.79	0.063	0.077	0.099	0.124
1.055	7.4	11	6.59	8.07	10.34	12.91	0.070	0.085	0.109	0.136
1.060	8.0	12	7.16	8.77	11.24	14.03	0.076	0.093	0.119	0.149
1.065	8.7	13	7.73	9.47	12.14	15.15	0.082	0.102	0.129	0.161
1.070	9.4	14	8.32	10.19	13.05	16.30	0.089	0.109	0.140	0.174
1.075	10.0	15	8.90	10.90	13.96	17.44	0.096	0.117	0.150	0.188
1.080	10.6	16	9.47	11.60	14.87	18.56	0.103	0.125	0.161	0.201
1.085	11.2	17	10.04	12.30	15.76	19.68	0.109	0.133	0.171	0.213
1.090	11.9	18	10.60	12.99	16.65	20.78	0.116	0.142	0.181	0.227
1.095	12.4	19	11.16	13.67	17.52	21.87	0.122	0.150	0.192	0.240
1.100	13.0	20	11.71	14.35	18.39	22.96	0.129	0.158	0.202	0.253
1.105	13.6	21	12.27	15.03	19.26	24.05	0.136	0.166	0.212	0.265
1.110	14.2	22	12.82	15.71	20.13	25.14	0.143	0.175	0.223	0.279
1.115	14.9	23	13.36	16.36	20.96	26.18	0.149	0.183	0.234	0.292
1.120	15.4	24	13.89	17.01	21.80	27.22	0.156	0.191	0.245	0.305
1.125	16.0	25	14.42	17.66	22.63	28.26	0.162	0.199	0.255	0.318
1.130	16.5	26	14.95	18.31	23.47	29.30	0.169	0.207	0.265	0.331
1.135	17.1	27	15.48	18.96	24.29	30.34	0.176	0.215	0.276	0.344
1.140	17.7	28	16.01	19.61	25.13	31.38	0.183	0.223	0.287	0.358
1.145	18.3	29	16.54	20.26	25.96	32.42	0.189	0.231	0.297	0.371
1.150	18.8	30	17.07	20.91	26.79	33.46	0.196	0.239	0.308	0.385
1.155	19.3	31	17.59	21.55	27.61	34.48	0.203	0.248	0.319	0.398
1.160	19.8	32	18.11	22.19	28.43	35.50	0.210	0.257	0.330	0.412
1.165	20.3	33	18.64	22.83	29.25	36.53	0.217	0.266	0.341	0.426
1.170	20.9	34	19.16	23.47	30.07	37.55	0.224	0.275	0.352	0.439
1.175	21.4	35	19.69	24.12	30.90	38.59	0.231	0.283	0.363	0.453
1.180	22.0	36	20.21	24.76	31.73	39.62	0.238	0.292	0.374	0.467
1.185	22.5	37	20.73	25.40	32.55	40.64	0.246	0.301	0.386	0.481
1.190	23.0	38	21.26	26.04	33.37	41.66	0.253	0.310	0.397	0.496
1.195	23.5	39	21.78	26.68	34.19	42.69	0.260	0.319	0.409	0.511
1.200	24.0	40	22.30	27.32	35.01	43.71	0.268	0.328	0.420	0.525
1.205	24.5	41	22.82	27.95	35.83	44.72	0.275	0.337	0.432	0.539
1.210	25.0	42	23.33	28.58	36.66	45.73	0.282	0.346	0.444	0.553
1.215	25.5	43	23.84	29.21	37.45	46.74	0.290	0.355	0.455	0.568
1.220	26.0	44	24.36	29.84	38.23	47.75	0.297	0.364	0.466	0.583
1.225	26.4	45	24.88	30.48	39.05	48.77	0.305	0.373	0.478	0.598
1.230	26.9	46	25.39	31.11	39.86	49.78	0.312	0.382	0.490	0.612
1.235	27.4	47	25.88	31.70	40.61	50.72	0.320	0.391	0.502	0.626
1.240	27.9	48	26.35	32.28	41.37	51.65	0.327	0.400	0.513	0.640
1.245	28.4	49	26.83	32.86	42.11	52.58	0.334	0.409	0.524	0.655
1.250	28.8	50	27.29	33.43	42.84	53.49	0.341	0.418	0.535	0.669
1.255	29.3	51	27.76	34.00	43.57	54.40	0.348	0.426	0.547	0.683
1.260	29.7	52	28.22	34.57	44.30	55.31	0.356	0.435	0.558	0.697
1.265	30.2	53	28.69	35.14	45.03	56.22	0.363	0.444	0.570	0.711
1.270	30.6	54	29.15	35.71	45.76	57.14	0.370	0.453	0.581	0.725

Specific Gravity at 15° 4° (in vacuo)	Degrees Baumé	Degrees Twaddell	100 parts by weight contain (as pure acid)				1 liter contains (reckoned as chemically pure acid)			
			SO ₂ %	H ₂ SO ₄ %	60° acid %	50° acid %	Kilo SO ₂	Kilo H ₂ SO ₄	Kilo 60° acid	Kilo 50° acid
1.275	31.1	55	29.62	36.29	46.50	58.06	0.377	0.462	0.593	0.740
1.280	31.5	56	30.10	36.87	47.24	58.99	0.385	0.472	0.605	0.755
1.285	32.0	57	30.57	37.45	47.99	59.92	0.393	0.481	0.617	0.770
1.290	32.4	58	31.04	38.03	48.73	60.85	0.400	0.490	0.629	0.785
1.295	32.8	59	31.52	38.61	49.47	61.78	0.408	0.500	0.641	0.800
1.300	33.3	60	31.99	39.19	50.21	62.70	0.416	0.510	0.653	0.815
1.305	33.7	61	32.46	39.77	50.96	63.63	0.424	0.519	0.665	0.830
1.310	34.2	62	32.94	40.35	51.71	64.56	0.432	0.529	0.677	0.845
1.315	34.6	63	33.41	40.93	52.45	65.45	0.439	0.538	0.689	0.860
1.320	35.0	64	33.88	41.50	53.18	66.40	0.447	0.548	0.702	0.876
1.325	35.4	65	34.35	42.08	53.92	67.33	0.455	0.557	0.714	0.892
1.330	35.8	66	34.80	42.66	54.67	68.26	0.462	0.567	0.727	0.908
1.335	36.2	67	35.27	43.20	55.36	69.12	0.471	0.577	0.739	0.923
1.340	36.6	68	35.71	43.74	56.05	69.98	0.479	0.586	0.751	0.938
1.345	37.0	69	36.14	44.28	56.74	70.85	0.486	0.596	0.763	0.953
1.350	37.4	70	36.58	44.82	57.43	71.71	0.494	0.605	0.775	0.968
1.355	37.8	71	37.02	45.35	58.11	72.56	0.502	0.614	0.787	0.983
1.360	38.2	72	37.45	45.88	58.79	73.41	0.509	0.624	0.800	0.998
1.365	38.6	73	37.89	46.41	59.48	74.26	0.517	0.633	0.812	1.014
1.370	39.0	74	38.32	46.94	60.15	75.10	0.525	0.643	0.824	1.029
1.375	39.4	75	38.75	47.47	60.83	75.95	0.533	0.653	0.836	1.044
1.380	39.8	76	39.18	48.00	61.51	76.80	0.541	0.662	0.849	1.060
1.385	40.1	77	39.62	48.53	62.19	77.65	0.549	0.672	0.861	1.075
1.390	40.5	78	40.05	49.06	62.87	78.50	0.557	0.682	0.873	1.091
1.395	40.8	79	40.48	49.59	63.55	79.34	0.564	0.692	0.886	1.107
1.400	41.2	80	40.91	50.11	64.21	80.18	0.573	0.702	0.899	1.123
1.405	41.6	81	41.33	50.63	64.88	81.01	0.581	0.711	0.912	1.138
1.410	42.0	82	41.76	51.15	65.55	81.86	0.589	0.721	0.924	1.154
1.415	42.3	83	42.17	51.66	66.21	82.66	0.597	0.730	0.937	1.170
1.420	42.7	84	42.57	52.15	66.82	83.44	0.604	0.740	0.949	1.185
1.425	43.1	85	42.96	52.63	67.44	84.21	0.612	0.750	0.961	1.200
1.430	43.4	86	43.36	53.11	68.06	84.98	0.620	0.759	0.973	1.215
1.435	43.8	87	43.75	53.59	68.68	85.74	0.628	0.769	0.986	1.230
1.440	44.1	88	44.14	54.07	69.29	86.51	0.636	0.779	0.998	1.246
1.445	44.4	89	44.53	54.55	69.90	87.28	0.643	0.789	1.010	1.261
1.450	44.8	90	44.92	55.03	70.52	88.05	0.651	0.798	1.023	1.277
1.455	45.1	91	45.31	55.50	71.12	88.80	0.659	0.808	1.035	0.292
1.460	45.4	92	45.69	55.97	71.72	89.55	0.667	0.817	1.047	1.307
1.465	45.8	93	46.07	56.43	72.31	90.29	0.675	0.827	1.059	1.323
1.470	46.1	94	46.45	56.90	72.91	91.04	0.683	0.837	1.072	1.338
1.475	46.4	95	46.83	57.37	73.51	91.79	0.691	0.846	1.084	1.354
1.480	46.8	96	47.21	57.83	74.10	92.53	0.699	0.856	1.097	1.370
1.485	47.1	97	47.57	58.28	74.68	93.25	0.707	0.865	1.109	1.385
1.490	47.4	98	47.95	58.74	75.27	93.98	0.715	0.876	1.122	1.400
1.495	47.8	99	48.34	59.22	75.88	94.75	0.723	0.885	1.134	1.417
1.500	48.1	100	48.73	59.70	76.50	95.52	0.731	0.896	1.147	1.433
1.505	48.4	101	49.12	60.18	77.12	96.29	0.739	0.906	1.160	1.449
1.510	48.7	102	49.51	60.65	77.72	97.04	0.748	0.916	1.174	1.465
1.515	49.0	103	49.89	61.12	78.32	97.79	0.756	0.926	1.187	1.481
1.520	49.4	104	50.28	61.59	78.93	98.54	0.764	0.936	1.199	1.498
1.525	49.7	105	50.66	62.06	79.52	99.30	0.773	0.946	1.213	1.514
1.530	50.0	106	51.04	62.53	80.13	100.05	0.781	0.957	1.226	1.531
1.535	50.3	107	51.43	63.00	80.73	100.80	0.789	0.967	1.239	1.547
1.540	50.6	108	51.78	63.43	81.28	101.49	0.797	0.977	1.252	1.563
1.545	50.9	109	52.12	63.85	81.81	102.16	0.805	0.987	1.264	1.579

Specific Gravity at 15° 40° (in vacuo)	Degrees Baumé	Degrees Twaddell	100 parts by weight contain (as pure acid)				1 liter contains (reckoned as chemically pure acid)			
			SO ₃ %	H ₂ SO ₄ %	60° acid %	50° acid %	Kilo SO ₃	Kilo H ₂ SO ₄	Kilo 60° acid	Kilo 50° acid
1.550	51.2	110	52.46	64.26	82.34	102.82	0.813	0.996	1.276	1.593
1.555	51.5	111	52.79	64.67	82.87	103.47	0.821	1.006	1.289	1.609
1.560	51.8	112	53.12	65.08	83.39	104.13	0.829	1.015	1.301	1.624
1.565	52.1	113	53.46	65.49	83.92	104.78	0.837	1.025	1.313	1.640
1.570	52.4	114	53.80	65.90	84.44	105.44	0.845	1.035	1.325	1.655
1.575	52.7	115	54.13	66.30	84.95	106.08	0.853	1.044	1.338	1.671
1.580	53.0	116	54.46	66.71	85.48	106.73	0.861	1.054	1.351	1.686
1.585	53.3	117	54.80	67.13	86.03	107.41	0.869	1.064	1.364	1.702
1.590	53.6	118	55.18	67.59	86.62	108.14	0.877	1.075	1.377	1.719
1.595	53.9	119	55.55	68.05	87.20	108.88	0.886	1.085	1.391	1.737
1.600	54.1	120	55.93	68.51	87.79	109.62	0.895	1.096	1.405	1.754
1.605	54.4	121	56.30	68.97	88.38	110.35	0.904	1.107	1.419	1.772
1.610	54.7	122	56.68	69.43	88.97	111.09	0.913	1.118	1.432	1.789
1.615	55.0	123	57.05	69.89	89.56	111.82	0.921	1.128	1.446	1.806
1.620	55.2	124	57.40	70.32	90.11	112.51	0.930	1.139	1.460	1.823
1.625	55.5	125	57.75	70.74	90.65	113.18	0.938	1.150	1.473	1.840
1.630	55.8	126	58.09	71.16	91.19	113.86	0.947	1.160	1.486	1.857
1.635	56.0	127	58.43	71.57	91.71	114.51	0.955	1.170	1.499	1.873
1.640	56.3	128	58.77	71.99	92.25	115.18	0.964	1.181	1.513	1.889
1.645	56.6	129	59.10	72.40	92.77	115.84	0.972	1.192	1.526	1.905
1.650	56.9	130	59.45	72.82	93.29	116.51	0.981	1.202	1.540	1.922
1.655	57.1	131	59.78	73.23	93.81	117.17	0.989	1.212	1.553	1.939
1.660	57.4	132	60.11	73.64	94.36	117.82	0.998	1.222	1.566	1.956
1.665	57.7	133	60.46	74.07	94.92	118.51	1.007	1.233	1.580	1.973
1.670	57.9	134	60.82	74.51	95.48	119.22	1.016	1.244	1.595	1.991
1.675	58.2	135	61.20	74.97	96.07	119.95	1.025	1.256	1.609	2.009
1.680	58.4	136	61.57	75.42	96.65	120.67	1.034	1.267	1.623	2.027
1.685	58.7	137	61.93	75.86	97.21	121.38	1.043	1.278	1.638	2.046
1.690	58.9	138	62.29	76.30	97.77	122.08	1.053	1.289	1.652	2.064
1.695	59.2	139	62.64	76.73	98.32	122.77	1.062	1.301	1.667	2.082
1.700	59.5	140	63.00	77.17	98.89	123.47	1.071	1.312	1.681	2.100
1.705	59.7	141	63.35	77.60	99.44	124.16	1.080	1.323	1.696	2.117
1.710	60.0	142	63.70	78.04	100.00	124.86	1.089	1.334	1.710	2.136
1.715	60.2	143	64.07	78.48	100.56	125.57	1.099	1.346	1.725	2.154
1.720	60.4	144	64.43	78.92	101.13	126.27	1.108	1.357	1.739	2.172
1.725	60.6	145	64.78	79.36	101.69	126.98	1.118	1.369	1.754	2.191
1.730	60.9	146	65.14	79.80	102.25	127.68	1.127	1.381	1.769	2.209
1.735	61.1	147	65.50	80.24	102.82	128.38	1.136	1.392	1.784	2.228
1.740	61.4	148	65.86	80.66	103.38	129.09	1.146	1.404	1.799	2.247
1.745	61.6	149	66.22	81.12	103.95	129.79	1.156	1.416	1.814	2.265
1.750	61.8	150	66.58	81.56	104.52	130.49	1.165	1.427	1.829	2.284
1.755	62.1	151	66.94	82.00	105.08	131.20	1.175	1.439	1.845	2.303
1.760	62.3	152	67.30	82.44	105.64	131.90	1.185	1.451	1.859	2.321
1.765	62.5	153	67.65	82.88	106.21	132.61	1.194	1.463	1.874	2.340
1.770	62.8	154	68.02	83.32	106.77	133.31	1.204	1.475	1.890	2.359
1.775	63.0	155	68.49	83.90	107.51	134.24	1.216	1.489	1.908	2.381
1.780	63.2	156	68.98	84.50	108.27	135.20	1.228	1.504	1.928	2.407
1.785	63.5	157	69.47	85.10	109.05	136.16	1.240	1.519	1.947	2.432
1.790	63.7	158	69.96	85.70	109.82	137.14	1.252	1.534	1.965	2.455
1.795	64.0	159	70.45	86.30	110.58	138.08	1.265	1.549	1.983	2.479
1.800	64.2	160	70.94	86.90	111.35	139.06	1.277	1.564	2.004	2.503
1.805	64.4	161	71.50	87.60	112.25	140.16	1.291	1.581	2.026	2.530
1.810	64.6	162	72.08	88.30	113.15	141.28	1.305	1.598	2.048	2.558
1.815	64.8	163	72.69	89.05	114.11	142.48	1.319	1.621	2.071	2.587
1.820	65.0	164	73.51	90.05	115.33	144.08	1.338	1.639	2.099	2.622

Specific Gravity 15° at 4° (<i>in vacuo</i>)	Degrees Baumé	Degrees Twaddell	100 parts by weight contain (as pure acid)				1 liter contains (reckoned as chemically pure acid)			
			SO ₃ %	H ₂ SO ₄ %	60° acid %	50° acid %	Kilo SO ₃	Kilo H ₂ SO ₄	Kilo 60° acid	Kilo 50° acid
1.821	—	—	77.63	90.20	115.59	144.32	1.341	1.643	2.104	2.628
1.822	65.1	—	73.80	90.40	115.84	144.64	1.345	1.647	2.110	2.635
1.823	—	—	73.96	90.60	116.10	144.96	1.348	1.651	2.116	2.643
1.824	65.2	—	74.12	90.80	116.35	145.28	1.352	1.656	2.122	2.650
1.825	—	165	74.29	91.00	116.61	145.60	1.356	1.661	2.128	2.657
1.826	65.3	—	74.49	91.25	116.93	146.00	1.360	1.666	2.135	2.666
1.827	—	—	74.69	91.50	117.25	146.40	1.364	1.671	2.142	2.675
1.828	65.4	—	74.86	91.70	117.51	146.72	1.368	1.676	2.148	2.682
1.829	—	—	75.03	91.90	117.76	147.04	1.372	1.681	2.154	2.689
1.830	—	166	75.19	92.10	118.02	147.36	1.376	1.685	2.159	2.696
1.831	65.5	—	75.35	92.30	118.27	147.68	1.380	1.690	2.165	2.704
1.832	—	—	75.53	92.52	118.56	148.03	1.384	1.695	2.172	2.711
1.833	65.6	—	75.72	92.75	118.85	148.40	1.388	1.700	2.178	2.720
1.834	—	—	75.96	93.05	119.23	148.88	1.393	1.706	2.186	2.730
1.835	65.7	167	76.27	93.43	119.72	149.49	1.400	1.713	2.196	2.743
1.836	—	—	76.57	93.80	120.19	150.08	1.406	1.722	2.207	2.755
1.837	—	—	76.90	94.20	120.71	150.72	1.412	1.730	2.217	2.769
1.838	65.8	—	77.23	94.60	121.22	151.36	1.419	1.739	2.228	2.782
1.839	—	—	77.55	95.00	121.74	152.00	1.426	1.748	2.239	2.795
1.840	65.9	168	78.04	95.60	122.51	152.96	1.436	1.759	2.254	2.814
1.8405	—	—	78.33	95.95	122.96	153.52	1.441	1.765	2.262	2.825
1.8410	—	—	79.19	97.00	124.30	155.20	1.458	1.786	2.288	2.857
1.8415	—	—	79.76	97.70	125.20	156.32	1.469	1.799	2.305	2.879
1.8410	—	—	80.16	98.20	125.84	157.12	1.476	1.808	2.317	2.893
1.8405	—	—	80.57	98.70	126.48	157.92	1.483	1.816	2.328	2.906
1.8400	—	—	80.98	99.20	127.12	158.72	1.490	1.825	2.339	2.920
1.8395	—	—	81.18	99.45	127.44	159.12	1.494	1.830	2.344	2.927
1.8390	—	—	81.39	99.70	127.76	159.52	1.497	1.834	2.349	2.933
1.8385	—	—	81.59	99.95	128.08	159.92	1.500	1.838	2.355	2.940

It readily absorbs moisture from the air. At a low temperature it solidifies to a crystalline mass which melts at a temperature of 10.5°. At the ordinary temperature it is the strongest of all acids.

The above table by LUNGE and ISLER gives the S. G. of sulphuric acid J various concentrations.

The following table by ANTHON shows the diminution in volume when H₂SO₄ (S. G. 1.84) is mixed with water.

10 % H₂SO₄ boils at 102°, 20 % at 105°, 30 % at 108°, 40 % at 114°, 50 % at 124°, 60 % at 141.5°, 70 % at 170°, 80 % at 207°, 90 % at 262.5°, and 95 % at 295°.

To avoid confusion with fuming sulphuric acid the ordinary concentrated commercial acid is generally termed (in Germany) English sulphuric acid. In Germany H₂SO₄ is the most important of all acids and indeed one of the most important industrial chemicals. It is used for so many purposes that it is impossible to mention them here.

TEST. The determination of the strength is usually calculated from the S. G. by the help of the preceding tables. For the rest, 2—3 g of H₂SO₄ are carefully weighed, diluted with H₂O and titrated with normal sodium hydroxide. Methyl orange is the best indicator but as small a quantity as possible must be used and care must be taken that the temperature is not above the normal. The test for impurities and the determination of their amount is carried out by the usual analytical methods.

100 parts by weight of water at 15–20° mixed with parts by weight of H_2SO_4 (S.G. 1.84)	Give acid of S. G.	100 parts by weight of water at 15–20° mixed with parts by weight of H_2SO_4 (S. G. 1.84)	Give acid of S. G.	100 parts by weight of water at 15–20° mixed with parts by weight of H_2SO_4 (S. G. 1.84)	Give acid of S. G.
1	1.009	130	1.456	370	1.723
2	1.015	140	1.473	380	1.727
5	1.035	150	1.490	390	1.730
10	1.060	160	1.510	400	1.733
15	1.090	170	1.530	410	1.737
20	1.113	180	1.543	420	1.740
25	1.140	190	1.556	430	1.743
30	1.165	200	1.568	440	1.746
35	1.187	210	1.580	450	1.750
40	1.210	220	1.593	460	1.754
45	1.229	230	1.606	470	1.757
50	1.248	240	1.620	480	1.760
55	1.265	250	1.630	490	1.763
60	1.280	260	1.640	500	1.766
65	1.297	270	1.648	510	1.768
70	1.312	280	1.654	520	1.770
75	1.326	290	1.667	530	1.772
80	1.340	300	1.678	540	1.774
85	1.357	310	1.689	550	1.776
90	1.372	320	1.700	560	1.777
95	1.386	330	1.705	570	1.778
100	1.398	340	1.710	580	1.779
110	1.420	350	1.714	590	1.780
120	1.438	360	1.719	600	1.782

To detect sulphurous acid the H_2SO_4 is treated with Zn and tested for H_2S with lead paper or with an alkaline solution of sodium nitroprusside formed from the SO_2 by reduction. If a quantitative determination is necessary, it is made by titration with a solution of iodine.

For nitrogen acids the best test is the well known one with diphenylamine. For nitrous acid m-phenyldiamine or GRIESS' reagent (see "REAGENTS" No. 28) is used. For the quantitative determination of the nitrous acid the sample should be titrated with KMnO_4 . The acid must be always added to the permanganate, never the permanganate to the acid. $\frac{1}{2}$ normal permanganate solution is diluted with five times the amount of warm water 30–40° and the sulphuric acid is allowed to flow into it from a burette with a glass stop cock, till the colour disappears. 1 ccm $\frac{1}{2}$ normal permanganate equals 0.0095 g N_2O_3 . If the amount of nitrous acid is very small, the test can be carried out colorimetrically with GRIESS's reagent. The total amount of nitrogen acids can be determined by means of a nitrometer. As a test for arsenic HAGER's kramato method, which according to LUNGE in "Chem.-techn. Untersuchungsmethoden" Vol. 1, Berlin, 1899, is carried out for H_2SO_4 as follows. In a porcelain basin 6 cm in diameter 20 drops of concentrated H_2SO_4 and 40 drops of H_2O are placed. This is then treated with 1.6 g of finely powdered sodium bi-carbonate and if, after stirring for 5 minutes, any part of the NaHCO_3 remains undissolved the mixture is warmed. Then 10 drops of ammonia and about 2 g of ammonium oxalate are added so that the H_2SO_4 is completely combined — this is absolutely necessary for the accuracy of the reaction — finally about 30 drops of HCl are added to render it strongly acid. A brass plate is then scoured with sand and carefully dried and on this one drop of the liquid is placed. The plate is warmed at first gently, then heated more strongly over a small flame. After washing the salt stain off there will

then be a spot left which will be grey to red or even black, according to the amount of As present. For the quantitative determination of As, HATTENSAUR'S method is recommended "Zeitschr. f. angew. Chem." 1896, 130. The method is as follows, 500 ccm H_2SO_4 are diluted with 500 ccm H_2O to which, 500 ccm diluted HCl , 1:2, are added, the mixture being cooled. While still cold, H_2S is passed through for one hour, and the precipitated As_2S_3 which is free from lead, filtered and washed in a platinum or porcelain Gooch crucible. It is washed with hot alcohol to remove traces of sulphur, dried, and the As_2S_3 weighed.

Instead of using a Gooch crucible the ppt. may be washed and dissolved in 20 ccm dilute NH_3 (1:2), the solution evaporated in a porcelain dish, oxidized to arsenic acid and the arsenic estimated as ammonium magnesium arsenate.

Sulphuric acid:

Brotherton & Co. Ltd., Clity Chambers, Leeds.

Sulphuric acid, fuming (NORDHAUSEN SULPHURIC ACID). This is a mixture of H_2SO_4 and SO_3 . Formerly the following process was always employed for its preparation. "VITRIOL SLATE" was sprinkled with 30 % of pyrites; this readily decomposes on exposure to the air giving FeSO_4 , and after a longer exposure $\text{Fe}_2(\text{SO}_4)_3$. After three years' exposure to the air the weather-worn vitriol slate was leached and the liquor evaporated to the consistency of a syrup. It was then allowed to trickle over flag stones and during this process the crude "vitriol stone" separates. This "vitriol stone" contains ferric- and some ferrous sulphate, besides the sulphates of Ca, Mg and Al. It was then calcined in ovens at a gentle heat; the H_2O was removed and the FeSO_4 converted into $\text{Fe}_2(\text{SO}_4)_3$. The calcined "stone" was then pulverized and subjected to dry distillation in earthenware retorts. Each retort contained 1—3 kg material; 30 to 35 such retorts lay side by side in a row, 3—4 rows deep in a so-called galley furnace. H_2O or H_2SO_4 was found in the receiver, while Fe_2O_3 (caput-mortuum) remained behind in the retorts.

Later fuming sulphuric acid was made chiefly from the NaHSO_4 obtained as a by-product in the manufacture of nitric acid (q. v.). The NaHSO_4 on being heated is first converted into sodium pyrosulphate $\text{Na}_2\text{S}_2\text{O}_7$, which decomposes on further heating into $\text{Na}_2\text{SO}_4 + \text{SO}_3$. The SO_3 is caught in H_2SO_4 . The Na_2SO_4 in the retort is again converted into NaHSO_4 by the addition of H_2SO_4 , which is then redistilled. A fused mixture of NaHSO_4 and MgSO_4 decomposes at a lower temperature than pure NaHSO_4 , yielding SO_3 .

After this, WINKLER'S PROCESS (see preceding article) became of importance; now, however this substance is obtained by the absorption in H_2SO_4 of the sulphur trioxide obtained by the contact process.

Fuming sulphuric acid is an oily, light-brown to colourless fluid which gives off SO_3 when exposed to the air. S. G. 1.86—1.90. When cooled to 0° , crystals of pyrosulphuric acid $\text{H}_2\text{S}_2\text{O}_7$ separate. This compound $\text{H}_2\text{S}_2\text{O}_7$, melts at a temperature of 35° decomposing into H_2SO_4 and SO_3 . Fuming sulphuric acid below 35° can therefore be considered as a solution of $\text{H}_2\text{S}_2\text{O}_7$ in H_2SO_4 , but above 35° as a solution of SO_3 in H_2SO_4 .

The following tables by CL. WINKLER show the density of the commercial acid at 20° .

TEST. The difficulty lies in the fact that the SO_3 evaporates at the ordinary temperature, that the acid is extremely hygroscopic and that it combines with H_2O with violence. The samples are therefore weighed in thin tubes

S. G. at 20°	Total SO ₃	100 parts contains			S. G. at 20°	Total SO ₃	100 parts contains		
		SO ₃ re- movable by distil- lation	H ₂ SO ₄	acid of 66° B _é			SO ₃ re- movable by distil- lation	H ₂ SO ₄	acid of 66° B _é
1.835	75.31	—	92.25	100.00	1.905	83.57	10.56	89.44	66.34
1.840	77.38	—	94.79	91.61	1.910	83.73	11.43	88.57	65.91
1.845	79.28	—	97.11	83.92	1.915	84.08	13.33	86.67	64.48
1.850	80.01	—	98.01	80.91	1.920	84.56	15.95	84.05	62.73
1.855	80.95	—	99.16	77.15	1.925	85.06	18.67	81.33	60.51
1.860	81.84	1.54	98.46	73.55	1.930	85.57	21.34	78.66	58.44
1.865	82.12	2.66	97.34	72.43	1.935	86.23	25.65	74.35	55.77
1.870	82.41	4.28	95.76	71.24	1.940	86.78	28.03	71.97	53.54
1.875	82.63	5.44	94.56	70.05	1.945	87.13	29.94	70.06	52.12
1.880	82.81	6.42	93.58	69.62	1.950	87.41	31.46	68.54	50.99
1.885	82.97	7.29	92.71	68.97	1.955	87.65	32.77	67.23	50.02
1.890	83.13	8.16	91.94	68.23	1.960	88.22	35.87	64.13	47.71
1.895	83.43	9.34	90.66	67.48	1.965	88.92	39.68	60.32	44.87
1.900	83.48	10.07	89.93	66.91	1.970	89.83	44.64	55.36	41.19

with glass stoppers and then poured into cold water, or the sample is weighed in sealed bulbs in which case the end is broken off under cold water.

To determine the strength, the sample is much diluted and titrated in the cold with N sodium hydroxide solution, methyl orange being used as indicator. The amount of sulphurous acid is determined by titration with a solution of iodine. For this and other tests compare also those given at the end of the article on "SULPHURIC ACID".

Sulphuric anhydride. Sulphur trioxide SO₃. This was formerly prepared by heating fuming sulphuric acid (q. v.), or by heating perfectly anhydrous Fe₂(SO₄)₃, or sodium pyrosulphate Na₂S₂O₇, either alone or mixed with MgSO₄. Of late it has been obtained by synthesis from SO₂ and O. This process is always said to be due to CL. WINKLER, but this is only true as regards the theoretical aspect of the case. WINKLER decomposes concentrated H₂SO₄ by intense heat, in earthenware retorts filled with pieces of quartz forming SO₂, H₂O and O, allows the steam to be absorbed by concentrated H₂SO₄, and conducts the dry gas through glazed porcelain tubes filled with platinized asbestos which are heated to a low red heat. The platinized asbestos (q. v.) acts as a contact substance and causes the combination of SO₂ and O to form SO₃. In this process WINKLER started on the assumption that only a mixture of SO₂ + O, in the proportions in which they are obtained by the decomposition of concentrated H₂SO₄, would produce SO₃ with the aid of finely divided platinum. In the WINKLER process sulphuric acid is sometimes used; it was formerly important in the manufacture of fuming sulphuric acid.

The new process, shortly mentioned in the article on "SULPHURIC ACID", is based in principle on this WINKLER method and is one which promises to revolutionize the whole manufacture of sulphuric acids. According to this new method the washed, dried, arsenic-free, furnace gases, SO₂ and O are passed over contact substances, when the reaction $2\text{SO}_2 + \text{O} = 2\text{SO}_3$ takes place. This contact process, discovered under the direction of R. KNIETSCH in the Badische Anilin- und Soda-Fabrik, differs from the WINKLER method, not only in the materials used but in the fact that the SO₂ and O need not be present in molecular proportions. The SO₂ may be mixed with any quantity of O (and of N) as in the furnace gases and the reaction proceeds in the same way.

In this process the receptacle containing the contact material is cooled from the outside, to lessen as much as possible the heat of the reaction which would otherwise unfavourably affect the product. This heat can be made use

of for the preliminary warming of the gases which take part in the reaction and lose their heat during washing. The process is described in detail in the Germ. Pat. 113932, 113933, 119059, 133713, &c. Only a few of the numerous changes and improvement in this process can be mentioned here. Many attempts have been made to substitute other compounds for the very expensive platinum metals. Germ. Pat. 105876, 109483, 107995, 108445, 108446, 119505, 136134, 140353, 142144, 142410, 149677 and others. Among such compounds, various kinds of pyrites residues, and oxides of different light and heavy metals especially Fe_2O_3 have been proposed. Of importance in this respect is the process given in the Germ. Pat. 128616 where vanadium compounds, and especially vanadic acid are used to advantage in place of platinum. The asbestos is soaked in a solution of ammonium vanadate, then dried and brought to a red heat. The catalytic effect of the vanadic acid continues undiminished even after it has been long exposed to the SO_2 and O mixture.

The Germ. Pat. 139554 advocates the preparation of SO_3 from furnace gases by the simultaneous burning of the sulphur present as sulphides in the pyrites residues. The method is as follows. The residues impregnated with ferrous sulphate are first treated with pyrites furnace gases at a low temperature, 300—400°. In this way SO_2 is fixed by the residue in consequence of the presence of iron compounds. If this be now heated, to 500°, the SO_2 will be set free to a certain extent in the form of SO_3 . Then follows the preparation of further quantities of SO_3 by contact effect. At the same time, in consequence of the moisture present in the gases, the sulphur still present in the refuse burns off. The process might be carried out in an economical fashion by continually passing the hot, impure gases escaping from the pyrites oven, into pyrites residues, impregnated with ferrous sulphate. Shortly after the introduction of the contact process into practice, it was found that the principal essential for the success of the method is a very careful purification of the gases and that even traces of impurities (more especially arsenic) are sufficient to destroy the effect of the contact materials. To revive the power of platinum, which has been destroyed by arsenic, the following method is given in the Germ. Pat. 135887. Steam is mixed with the hot gases streaming into the contact chamber, until the reaction gases escaping no longer show the presence of arsenic. The arsenic compounds adhering to the platinum are rendered volatile by this method. When no arsenic can be detected in the condensed acid, dry gas is again admitted and the platinum contact soon regains its former efficiency.

The Germ. Pat. 142895 gives another process as follows. The inactive contact material is purified by mixing small amounts of volatile halogen compounds with the gases till the impurities of the contact material are volatilized and have escaped. As suitable halogen compounds, the patent mentions hydrochloric acid gas, sal ammoniac, chloride of sulphur, sulphurylchloride, phosgene and organic chlorides.

The Germ. Pat. 148196 protects a method for reviving inactive platinum contact material by means of dry sulphurous acid (gases from pyrites ovens with a high percentage of SO_2), which is allowed to act on the inactive material at a high temperature.

The Germ. Pat. 154084, LUNGE'S PROCESS, is of special interest and value and is carried out as follows. The metallic oxide (Fe_2O_3 is the best) which serves as contact substance, is mixed with some arsenical material, so that the whole contains 5 % or more of arsenic, that is, more than freshly burnt ore. After this the gases from arsenical iron pyrites is passed over the contact substance which must be frequently renewed.

The principle of the contact process is based on the strict exclusion of H_2O , but we must mention that there are some methods which proceed on exactly opposite lines and indeed pump steam into the mixture. We may add however

that these inventions do not seem to be carried out in practice. The Germ. Pat. 157767 deals with a contact process by which H_2SO_4 is directly formed without the intermediate formation of SO_3 . The contact substance is said to be granulated silicon. It is connected with the poles of an electric system. The pyrites gases are drawn through the contact substance while the latter is at the same time sprinkled with water. The electrolytic decomposition of H_2O which occurs produces a part or the whole of the O necessary for the oxidation of the SO_2 .

It is impossible here to quote the countless patents which deal with changes or improvements in contact methods. The most important, however, are those quoted above. For the rest, there is no doubt that certainly many of the newer patents are of no importance whatever for practical purposes, and for reasons easily understood the public hears very little as to whether they are of any commercial value. See Germ. Pat. 163835, 164722, 169728, 178762, 179588, and 187077.

By dissolving the SO_3 in H_2O , sulphuric acids of any desired strength can be obtained. Or the vapour of SO_3 is allowed to react with 50% H_2SO_4 in a reaction tower. In this way sulphuric acids of any concentration or any desired amount of anhydride can be produced. The new process effects a considerable economy of fuel and also prevents the great waste of nitre necessitated by the old H_2SO_4 process.

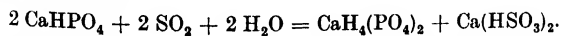
SO_3 can also be transported more economically than H_2SO_4 , being more concentrated.

Pure SO_3 below $+16^\circ$ is a solid mass of crystalline needles similar to asbestos. Above this temperature it is a colourless liquid S. G. at 20° of 1.97, B. P. 46.2° . It is extremely hygroscopic, fumes strongly on exposure to air, dissolves in H_2O with a hissing noise (when dealing with large quantities it may become explosive) with formation of H_2SO_4 .

Sulphur dioxide. SO_2 . Sulphur is burnt in a furnace with a good draught and the gases passed through several layers of water. Concentrated solutions are obtained by boiling H_2SO_4 (about 62° Bé) with charcoal. The decomposition corresponds to the equation $2\text{H}_2\text{SO}_4 + \text{C} = 2\text{SO}_2 + 2\text{H}_2\text{O} + \text{CO}_2$. A small quantity of SO_3 is also formed as a by-product. To obtain pure liquid SO_2 the gases from pyrites or blende (see "SULPHURIC ACID") are allowed to meet with falling H_2O in an absorption tower. The SO_2 solution is then heated to boiling point in lead pans when the SO_2 escapes. The vapours enter a pipe cooled by water and from there pass again into a boiler into which concentrated H_2SO_4 is pumped. This H_2SO_4 removes the H_2O from the gas. The dry SO_2 then enters first a compression pump and then a cooling pipe, where the gas condenses. All the gases from the works must pass through absorption towers filled with chalk or through those in which H_2O falls, otherwise the SO_2 causes damage to the surrounding vegetation.

Other processes for the preparation of liquid SO_2 are less important. One method of this kind is that of freezing out the water from aqueous solutions.

According to Germ. Pat. 160940 dicalcium phosphate in presence of H_2O is a very good absorbent for SO_2 . During absorption bisulphite and acid phosphate are formed.



By slightly heating (not above 100°) the SO_2 is again driven out, when the dicalcium phosphate is regenerated and can then be immediately employed again as an absorbent. By this process the SO_2 can be obtained from comparatively poor gases.

SO_2 is a colourless, pungent-smelling gas with poisonous properties. S. G. 2.2112 (air = 1). It dissolves in H_2O at the ordinary temperature, while at

a lower temperature the real sulphurous acid hydrate H_2SO_3 seems to be formed temporarily.

HARFF has compiled the following tables giving the solubility of sulphur dioxide:

Temp. ° C	1 L. H_2O dissolves Litres SO_2	1 L. H_2O dissolves grams SO_2	1 L. aqueous sat. sol. contains Litres SO_2	S. G. of aqueous solution	Increase of Vol. from 1—	percentage of SO_2 in the aqueous solution
0	79.8	228.3	228.3	1.0609	1.158	18.58
5	67.5	193.1	59.82	1.059	1.127	16.16
10	56.6	161.9	51.38	1.0547	1.102	13.93
15	47.3	135.3	43.56	1.042	1.090	11.92
20	39.4	112.7	36.21	1.0239	1.087	10.13

The following tables compiled by SCOTT give the S. G. of aqueous solutions of SO_2 , and their contents at a temperature of 15° C.

S. G.	SO_2 %	S. G.	SO_2 %	S. G.	SO_2 %	S. G.	SO_2 %
1.0028	0.5	1.0168	3.0	1.0302	5.5	1.0426	8.0
1.0056	1.0	1.0194	3.5	1.0328	6.0	1.0450	8.5
1.0085	1.5	1.0221	4.0	1.0353	6.5	1.0474	9.0
1.0113	2.0	1.0248	4.5	1.0377	7.0	1.0497	9.5
1.0141	2.5	1.0275	5.0	1.0401	7.5	1.0520	10.0

The gas can be condensed at normal temperature at a pressure of about 3 atm. The liquid SO_2 is colourless and mobile. S. G. 1.49 at — 20°; B. P. — 8°; F. P. — 76°. Special rules are laid down for transport by rail.

SO_2 is used in many different ways. It is used for obtaining H_2SO_4 , sulphates, thio-sulphates, sulphides, S from H_2S , &c. It is used for bleaching silk, wool, feathers, glue and paper. The gas is a preservative for wine, grapes and hops. It is used as a disinfectant, and for extinguishing fires. Further it is used for the manufacture of ice. In the liquid state it makes an excellent lubricant and according to a certain patented process it is used for extracting fats and oils.

TEST. Solutions of SO_2 in H_2O can be estimated by the above tables, unless there are impurities present (H_2SO_4 is frequently present). For accurate determination the gas is titrated with N NaOH solution with phenolphthalein as indicator.

Superphosphate (Acid calcium phosphate; monocalcium phosphate). An artificial manure produced from tri-calcium phosphate by treatment with H_2SO_4 . The raw materials are natural phosphates like coprolites, phosphorites, phosphatic guanos, also artificial products like bone meal and bone ash. The quality of the superphosphate produced is to a great extent dependent on the quality of the raw material.

In the treatment with H_2SO_4 1 part of the tri-calciumphosphate is decomposed with formation of CaSO_4 ; the phosphoric acid formed at the same time slowly converts the remaining tri-calcium phosphate $\text{Ca}_3(\text{PO}_4)_2$ into monocalcium phosphate $\text{CaH}_2(\text{PO}_4)_2$. The mixture of monocalcium phosphate with CaSO_4 is called superphosphate. When an insufficient amount of H_2SO_4 has been used part of the monocalcium phosphate is converted into dicalcium phosphate $\text{Ca}_2\text{H}_2(\text{PO}_4)_2$ by the unaltered tri-calcium phosphate. This $\text{Ca}_2\text{H}_2(\text{PO}_4)_2$ is insoluble in H_2O though soluble in ammonium citrate; i. e. the amount of water-soluble phosphoric acid decreases while that of citrate-soluble

H_3PO_4 increases. The same phenomenon is observed if the original raw material contains iron in any form.

The material chiefly used in the manufacture of superphosphate is H_2SO_4 (chamber acid). If the material is very moist it has to be first dried; only where concentrated H_2SO_4 can be obtained cheaply may the drying be omitted. After drying the phosphates are finely ground and then mixed with H_2SO_4 in bricklined vessels or in special mixing machines (the latter is now the more frequently used method). The objectionable gases HCl , HF and SiF_4 are blown into a tower by steam and condensed by water, soda solution or milk of lime. A by-product of the manufacture is hydrofluosilicic acid.

The substance after mixing has to be stored for 1–2 months in airy sheds and be turned as little as possible. If this time is more than can be afforded, or if the superphosphate appears to be too moist it has to be turned more often or be dried artificially. When dry it is crushed and sifted. Frequently the material is crushed while still warm; the resulting powder dries very rapidly.

Commercially superphosphates are known by names generally derived from the kind of material used in their manufacture. The amount of phosphoric acid (water-soluble + reduced) is also given. As a rule superphosphates contain 20 % water-soluble H_3PO_4 .

Double superphosphates are manures containing about double the amount of water-soluble H_3PO_4 found in the ordinary superphosphates. Free phosphoric acid is prepared by decomposing phosphorites, the gypsum separated from the H_3PO_4 solution by cooling and the residue evaporated in pans to 56° Bé. After cooling bone charcoal or phosphatic guano is stirred into the concentrated solution in sufficient quantities to produce monocalcium phosphate. The solid paste is dried by hot air and crushed.

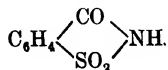
Ammonia-superphosphate is a mixture of superphosphate with ammonium sulphate in varying proportion. It is used as a manure.

See also "MANURES, ARTIFICIAL".

Suprarenine see "ADRENALINE".

Sweetening substances, artificial.

1. SACCHARINE, anhydro-o-sulphamidobenzoic acid, or benzoic acid sulphimide.

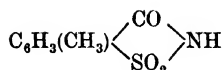


Toluene is sulphonated with concentrated H_2SO_4 at a temperature not above 100°. The resulting o- and p-toluene monosulphonic acids are first converted into the Ca-salts and then into the Na-salt. The dry Na-salts are treated with PCl_5 and Cl , the POCl_3 formed is distilled off, and the mixture of o- and p-toluene sulphochlorides strongly cooled. The p-compound crystallizes out while the o-sulphochloride remains liquid and is separated by centrifuges. By the action of NH_3 on the latter o-toluolsulphamide is formed, which passes into o-benzoic-sulphaminic acid K by oxidation with KMnO_4 . By adding acids to the latter, water and crystals of SACCHARINE, separate.

It is a white, odourless powder, very sparingly soluble in H_2O , M. P. 224°. By treatment with alkali carbonates easily soluble saccharine is obtained. Saccharine is also produced electrolytically by a patented method from o-toluene sulphamide in alkaline solution.

Other artificial sweet substances are, by constitution either the same as saccharine, as for instance.

2. SANDOCE, or
3. METHYL SACCHARINE.



Others are:

4. DULCINE (SUCROL) = phenetolcarbamide.
5. GLUCINE, i. e. amidotri-azinesulphonic acid and its Na-salt.

Syrup. A more or less purified saturated, viscid aqueous solution of sugar obtained as a by-product in the manufacture of sugar. Compare Invert Sugar, Molasses, Glucose and Sugar manufacture. For pharmaceutical purposes and for making liqueurs, lemonade, &c. pure syrups are prepared by dissolving sugar in water. Fruit syrups contain the aromatic principles of the various fruits.

Syrup-manufacturing plants:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Syrup-vacuum apparatus:

Friedrich Heckmann, Berlin SO. 16. Brückenstr. 6b (see advts.).

Determination of the water contents with Abbe's Refractometer Prosp. Mess. 172:

Carl Zeiss, Jena (Germany).

T

Taeniol. GOLDMAN has discovered a substance called *Sebirol* in various species of *Embelia* which when mixed with dithymolsalicylate and turpentine oil is a specific for the ankylostomiasis of miners, and for intestinal worms.

The combination mentioned is sold in gelatine capsuls as "Taeniol".

Talc. A hydrated magnesium silicate (hardness = 1) with a greasy touch; it marks cloth, and burns hard when strongly heated. Talc in the narrower sense (*Talcum venetum*) used as a white colour, as a polishing and lubricating agent, should be distinguished from soapstone (q.v.) the still harder Chinese soapstone and Spanish or Venetian chalk.

Talc:

Afenzler Grafit- und Talksteingewerkschaft G. m. b. H., Afenz (Austria).

Tallow. The fat of oxen (beef tallow) and of sheep (mutton tallow) is hard, colourless, has a characteristic smell and consists usually of 75 % stearine and palmitine and 25 % oleine. Mutton tallow is harder than beef tallow, M. P. 46.5—47.5°. Beef tallow M. P. 43.5—45°.

The crude fat is first washed with water to remove blood and impurities and then pressed in shredding apparatus to destroy the cell walls. This is followed by melting (rendering) either in the dry or wet way. The dry melting is performed over an open fire, while by the other method the tallow is melted over water or by steam. The crude tallow must be quickly worked up, otherwise the blood and other impurities undergo putrefaction. The tallow is generally rendered at 60—65° and after standing for a short time poured off from the impurities and pressed at 35°. The residue is *prima pressed tallow*, the pressed out fat is *oleo margarine*, used for making margarine, while the former is valued for candle making. If the tallow is pressed at a lower temperature tallow oil is obtained. This is used as a lubricant and as a constituent of lubricating mixtures.

The dry rendering is carried out in open brick-work vessels with constant stirring, the temperature being raised gradually: the flames must touch only the bottom of the pan. At 100° the mass begins to boil and continues to do so until the water is all driven off. The surface then remains still and the clear fat is poured through a filter while from the residue (*greaves, crackling*) the adhering fat is removed in presses. This residue is used as a cattle food and also after the fat is completely extracted with CS_2 , for the manufacture of ferrocyanides (see "IRON COMPOUNDS"). The unpleasant vapours emitted during the melting process are best removed by leading them back into the furnace. LUDOFF recommends melting the tallow in a partial vacuum (350—400 mm).

On a large scale the rendering is carried out in the wet way. The steam is either produced in the melting pot itself or is introduced from a boiler at a pressure of 1.5 to 2 atmospheres. The tallow is placed with H_2O in the melting pots which are either open wooden vessels lined with lead, or autoclaves. Some H_2SO_4 , NaOH or Na_2CO_3 is usually added to increase the yield. In this case too the objectionable vapours are generally burnt.

For some purposes the tallow must be refined. Melting over boiling water for some time, constantly stirring and then filtering is generally sufficient, but sometimes it is treated with H_2SO_4 and MnO_2 or with H_2SO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$. It may also be melted with the addition of HNO_3 or alkalis, or decolourized with animal charcoal, clay, SO_2 , ozone, KMnO_4 , H_2O_2 , BaO_2 , &c. These may interfere with the quality of the product as regards its saponification properties. Tallow is used for the preparation of margarine, candles, soap, stearic acid, lubricants and in leather dressing.

According to Norweg. Pat. 12410 a substitute for tallow is obtained from blubber by mixing with H_2SO_4 and then adding nitrites. Steam is then introduced and the tallow purified by distillation. The process seems to be expensive. The product consists of fatty acids.

Tallow Melting Plant:

G. Scott & Son Ltd., 2 Talbot Court, London E.C.

Tallow, vegetable. Solid vegetable fats similar to tallow. Chinese tallow (*Oleum Stillingiae*) obtained from the seeds of *Stillingia sebifera*, Malabar tallow obtained from the "butter beans" of *Vateria indica* (India) and Mafurrah tallow obtained from the nuts of *Trichilia emetica* are included under this heading.

Japan wax from *Rhus succedanea* (China and Japan) and the myrica wax obtained from the berries of different kinds of *Myrica* (America) must be included as they are genuine fats, yielding glycerine on saponification.

Tanks.

Iron Tanks:

Kleins, Neuschaefer & Co., Schwelm i. W., Germany.

Tannal. A basic aluminium tannate. Used medicinally.

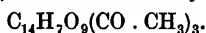
Tannalbine. An albumin compound of tannic acid, used as an intestinal astringent in catarrh of the large intestine.

Tannaline films. Gelatine films hardened by formaldehyde used for photographic purposes.

Tannalum. There is *tannalum solubile*, i. e. aluminium tannate, and *tannalum insolubile*, i. e. basic aluminium tannate. The latter is obtained by precipitating an $\text{Al}_2(\text{SO}_4)_3$ solution by a solution of tannic acid in NH_3 .

When this brown powder, insoluble in H_2O , is dissolved in a solution of tartaric acid and evaporated tannalum solubile is formed.

Tannigen. Acetyl tannin, or more accurately tri-acetyl tannin.



Produced according to Germ. Pat. 78879 by heating tannic acid with acetic anhydride in presence of acetic acid or acetic ether.

Yellowish grey tasteless, odourless powder, sparingly soluble in H_2O . Used as an intestinal astringent in chronic diarrhoea. First dose 0.75 g; then 0.5 g every three hours. For children half the above.

Tannin or Tannic acid. $C_{14}H_{10}O_9$. This is the anhydride of gallic acid. Tannin is the most active constituent of all materials used for tanning; see "TANNING MATERIALS"; it has the special characteristic of rendering animal fibres insoluble, forming leather. See also the article on "TANNING". Tannic acid is widely distributed in the vegetable kingdom vegetation. It is obtained from the sumach and galls. See "GALLS".

Commercially a distinction is drawn between *water tannin*, *alcohol tannin* and *ether tannin* according as the substance has been obtained from the sumach or galls by one or other of these three solvents. The best of the three is ether tannin, called *foam tannin*.

The galls are first broken in mills and then ground to a coarse powder. The powder is then placed in a diffusion apparatus, of which several are joined together to form a battery. (Cf. SUGAR MANUFACTURE for the principle of the diffusion process.) The aqueous tan liquor obtained by this principle is next filtered until clear and bright. It is then extracted with ether, which must be done in copper mixing vessels fitted with stirring apparatus. The ether employed for the shaking is the product obtained in the first rectification of crude ether, that is an ether containing water and alcohol. After being well mixed the whole of the liquid remains for 8—10 days in barrel-shaped vessels, after which the thick layer at the bottom which contains the tannin is freed by distillation in suitable vessels from the ether which is present.

The syrupy tannin which remains behind is dried either on large rotating cylinders or spread out on sheets of zinc plate and placed in a drying chamber. After steam has been passed for a very short time over the dried tannin on the zinc plate sheets, a light coloured and specifically light porous tannin is obtained. Water and alcohol tannins are less pure than this kind. Tannin comes into the market as a yellow powder or in crystal-like scales or leaves. It dissolves in 1 part of water, 2 parts of alcohol, 8 parts of glycerine and in acetic ether. In ether, chloroform, benzine, benzene and carbon bisulphide it scarcely dissolves at all.

The largest quantity of the tannin produced is used as a mordant. Some is employed for clarifying beer and wine and some for making ink and pyrogallol. Compare "INK" and "PYROGALLOL". The product is also of considerable importance medicinally.

TEST. The water determined by drying at a temperature of 100° should not exceed 12 %, the ash should not exceed 0.2 %. To test for sugar, dextrine or extractives 10 ccm of a solution of tannin (10 g + 50 g H_2O) is mixed with 10 ccm % alcohol when the solution should remain clear. Also on adding 5 ccm of ether the solution should show no signs of clouding. For details of the hide-powder method see "TANNING MATERIALS".

DREAPER, Chem.-Ztg., Report. 1904, 270, describes a method for the determination of tannic and gallic acid, which is said to give more satisfactory results than the skin powder process. The following solutions are necessary

for this test. 1. Solution of copper sulphate = 0.05 g CuO in 1 ccm; 2. 50 g $(\text{NH}_4)_2\text{CO}_3$ and 50 g sodium sulphite in 1 liter; 3. 20 g lead acetate and 60 ccm glacial acetic acid. — I. 50 ccm of the sample solution containing 10–15 g tannin per liter are heated with excess of calcium carbonate, then cooled and titrated with the copper sulphate solution 1. Ferrocyanide serves then as indicator. One drop is laid on a double layer of filter paper and pressed in with a glass rod. The under layer which is saturated with the clear ferrocyanide, solution is used for the test. The result, expressed in CuO, gives the total amount of tannin and gallic acid. This from the standpoint of the dyer is considered as the mordanting power. II. 50 ccm of the tannin solution is treated with 25 ccm of the second solution and titrated with solution 1. The ferrocyanide which again serves as indicator must be strongly acidified with acetic acid. Copper tannate separates free from salts of gallic acid. The titration is very slow towards the end and it takes from 2–3 minutes for the final reaction colour to appear. When the constituents of the solution are unknown, the residue must be filtered off and weighed after drying at 105° . As the quantity of CuO is known the amount of tannic acid present can be easily calculated. III. 50 ccm of the sample solution are treated with 10 ccm of solution 3, in presence of barium sulphate, then well shaken and put through dry filtering paper. The filtered solution is then treated with anhydrous sodium sulphate to remove the lead. After 5 minutes it is again passed through a dry filter; 40 ccm of the filtrate are warmed with calcium carbonate and then titrated as given for I. The gallic acid is estimated by this, and, from the difference, the tannic acid.

Tannin plants:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Tannin evaporating apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Tanning. The process of tanning consists in the treatment of hides with tanning materials whereby they are converted into leather, that is to say they are no longer hard and horny, but remain pliable on drying.

In the preparation of leather the hides of cattle, calves, horses, deer, lambs, sheep, goats, &c. are used. All skins must be submitted to a series of processes before the actual tanning; these are as follows:

1. **SOAKING.** By steeping the hides for some hours blood and other impurities are removed. If they have been previously dried or salted the soaking must be prolonged. The hides are then fleshed, that is to say, the flesh and fat adhering to them are removed by scraping with knives.

2. **LOOSENING OF THE HIDE AND UNHAIRING.** This is accomplished in various ways. The hides are folded together, flesh sides inwards and "sweated" for 30 to 40 hours in a sweating chamber. Acid fermentation sets in and the hair is loosened, while the hide swells. This process requires very careful watching. In "liming" the hides are placed in weak milk of lime that has been previously used and then into a stronger solution of the same. They remain in this for a period varying from 2 to 8 days. The addition of caustic alkalies makes the process more rapid. Calcium sulphide, calcium hydrosulphide, sodium sulphide, arsenic sulphide and other substances have also been used for unhairing.

3. **PLUMPING AND PURING.** The unhaired hide is then subjected to a process which removes the lime and causes the hide to swell so that it can readily take up the tanning material. The plumping depends upon the action of organic acids. The "white pure" is made from bruised barley or bran mixed with sour dough and water: the lactic acid which is formed causes the plumping. In red puring an aqueous extract of spent tan is used: the

activity of this depends on the presence of lactic and acetic acids. In some cases sulphuric, hydrochloric and phosphoric acids are employed but in this cases great care must be exercised in order to avoid injury to the hide. A lactic acid preparation sold under the name vegetaline (*q. v.*) is also used for this purpose.

4. PICKLING. This consists in the treatment of the wet hides previous to tanning by the two-bath chrome method. The pickle is prepared with common salt to which sulphuric acid is added. According to EITNER for every 50 kg of wet hides 10 kg of NaCl in 100 litres of H_2O to which 1—2 litres of H_2SO_4 are added is used.

According to Germ. Pat. 135844 tanning may be carried out with the help of certain kinds of tar dissolved in turpentine, phenol, &c. It is doubtful whether this method is of any value.

French Pat. 328853 protects a method for quick tanning. According to this the hides are tanned in drums into which air or ozonised air is introduced. The skins are previously treated with H_2O_2 . This method, due to FAHRION, appears to be rational when considered in conjunction with the chrome method.

In the tanning process proper, that is with tannin materials, the skins are treated as above described. The tan liquor is then prepared from various substances such as oak bark, hemlock bark, &c. The outer layers of the bark contain the bulk of the tannin. These barks are disintegrated in mills and an extract made. In the older process the hides were placed in pits about 3 metres deep lined with cement, alternately with the tan and then covered with water or spent tan liquor and left for several months.

It is important that the tanning should take place slowly and this is accomplished by using weak liquors at first and gradually increasing the concentration. If this is not done the external layers only become tanned and the inner portions are not attacked by the tannin. The hides are turned so that the flesh sides which were formerly above are placed underneath. This turning must be repeated until the hide is thoroughly tanned. This can be ascertained by the fact that when cut the leather shows a dark brown colour. According to the thickness this process takes from 1 to 3 years.

Thick sole leather is best prepared by this method, but for other hides the quick method may be employed. This depends upon the principle of steeping the hides in an infusion of the tanning material. The bath must at first be weak (0.2—0.3° Bé) and in this the hides are left for two to three weeks, after which they are removed to a stronger bath (0.5 Bé) and the strength gradually increased to 1.5—2.5°. The number of baths and the duration of the process depend on the thickness of the leather (generally from 30 to 75 days are necessary). The hides are then washed with water, allowed to drain and the flesh sides brushed with oil (blubber) to prevent the cracking of the leather. The leather must be dried very slowly at a temperature below 30°. See also MINERAL TANNING.

Tanning extracts. Artificial tanning extracts are now very frequently brought on the market in place of the solid materials. The extracts of oak and chestnut wood find a ready sale.

Tanning extracts are made by the diffusion processes exactly in the same way as colour extracts. The extracting process which takes 7—8 hours gives a product which can either be used as it is, or which has to be evaporated *in vacuo*. The extracts ready for use can be obtained dry, as solids, or liquids (30° Bé). The contents of such extracts, however, vary considerably and depend on concentration. The extracts vary in strength between 20 and 60%. Between 11 % and 57 % of pure tannin have been found.

There are several new methods which have been brought forward for the preparation of tanning extracts. Germ. Pat. 132367 and 149148 aim at the

continuous extraction of tanning materials by centrifugal force. According to the first named patent the materials are spread by centrifugal force in thin coatings over the sides of a sieve cylinder widened at the bottom. The material trickles slowly down while the extracting agent is thrown up through the tanning material. The second patent uses several sets of centrifugal apparatus placed side by side so that the liquid is thrown from the first into the second and again passing through the tanning material into the third and so on.

Engl. Pat. 11502 (1902) deals with the treatment of tanning materials for removing the colour. This, it is ascertained, can be done by heating the extract with powdered metals such as Sn, Zn or Al, when the dark coloured tan is converted into lighter products. The extracts in this case are also said to be soluble in H_2O .

According to Amer. Pat. 740283 tanning extracts soluble in H_2O are obtained by treating the crude solutions first with ammonium sulphate then with sodium bisulphite and finally heating the mixture under 2—3 atm. pressure to about 120—130°.

Germ. Pat. 132224 and 152236 treat of the production of tanning extracts by means of the waste liquors from the sulphite cellulose industry; the product being, it is said, readily soluble and of a fine pale colour.

Tanning extract plants:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Tanning materials. This name includes only the tanning materials of vegetable origin, and not those in the so-called mineral tanning. The following table gives the most of important materials used and the percentage of tannin contained:

	Percentage of tanning substance		Per- centage of tanning sub- stance
Oak best	16—20	Mangle bark (S. America)	23—33
“ good	12—15	Monesia bark (Brazil)	30
“ medium	10—12	Mangrove (Africa)	40
“ poor	7—9	Mimosa (Australia)	30
“ old	5—10	Shumac	
Pine (pitch) young	8—10	(leaves and twigs of different	
“ “ old	6—7	species of <i>Rhus</i>	12—23
Willow, young	8—12	Valonia	20—45
Larch	6—8	Quebracho	18—22
Fir	4—8	Divi-divi	30—50
Birch	3—5	Myrobolans	15—40
Elm	4—5	Galls, China	70—77
Beech	3—4	“ Asiatic	55—60
Horse chestnut	2—3	“ South European	25—30
Persea (Chili)	17—18	Catechu	25—60
Curtidor bark (S. America)	20—24		

Tannobromine. Prepared (according to Germ. Pat. 125305) from formaldehyde and di-bromtannic acid.

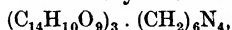
Reddish-grey powder, slightly soluble in H_2O , readily in alkaline liquids. It is said to be prescribed internally for diseases of the stomach and intestines. SAALFELD has used it successfully as an external preventive of premature loss of hair.

Tannochrome. A compound of chromium oxide; tannin and resorcin, said to be used for the skin.

Tannocol. A compound of glue and tannin, obtained by precipitating a gelatine solution with tannic acid. It is a slightly yellow, odourless powder, an excellent intestinal astringent. Dose 1 g for adults, 0.5 g for children, several times a day.

Tannoform. Methyl-di-tannin, obtained by the action of formaldehyde on tannic acid. It is an antiseptic, used internally for intestinal catarrh. Dose 0.5—1.0 g, for children 0.1—0.25 g. Used with success in treating wounds, gatherings, &c. Mixed with talc 1 : 2 it is a good anti-perspiration powder.

Tannone (Tannopine). Hexamethylenetetramine tannin



obtained by condensing tannin with hexamethylenetetramine (q. v.). It is a good intestinal astringent, prescribed in cases of typhoid fever, inflammation of the intestines &c. Dose for adults 1 g, for children 0.25—0.5 g, four to eight times per day.

Tanosal (Creosote tannate, creosal). Obtained by the action of phosgene on a mixture of tannic acid and creosote. It is used as a substitute for creosote, especially for consumption.

Tantalum. Ta. A. W. = 182.5. A rare element, always found together with niobium. Formerly Ta had no industrial importance whatever; at present however it is valuable, especially since the construction of tantalum lamps (q. v.).

Ta is obtained by various methods, for instance from tantalic acid and carbon in electric furnaces, or by the reduction of the oxides with sodium. These methods do not, however, produce pure metallic tantalum. Ta, free from all impurities may be prepared by two methods discovered by SIEMENS & HALSKE. By the first, white tantalic acid (tantalum pentoxide) is made into small rods with paraffin and converted into brown tantalum tetroxide in presence of powdered carbon at 1700° C. The bow-shaped, electrically conducting brown rods are placed in highly evacuated glass globes, and a current is sent through the rods. The tantalum tetroxide evolves oxygen, leaving pure Ta.

In order to prepare greater quantities of Ta, potassium tantalum fluoride $\text{TaF}_5 \cdot 2 \text{KF}$ is heated with Na. This Ta is not, however, quite pure. It is purified according to Germ. Pat. 155548 by melting in the electric arc, preferably *in vacuo*. For this purpose the crude metal must be strongly compressed to ensure electrical conductivity. The electrodes should not be of carbon but of metal, if possible of tantalum itself.

Pure Ta has a M. P. between 2250 and 2300°; S. G. of the pure metal (in bars) 16.64, of a strongly stretched thin wire 0.05 mm in diameter 16.5. The specific heat (between 16 and 100° C) is 0.0365. The linear coefficient of expansion = 0.0000079; the mean specific resistance (1 m length and 1 square-mm cross section) is 0.165; the temperature coefficient between 0 and 100° is 3 %/100, between 0 and 350° is 2.6 %/100. The resistance increases with the temperature and reaches 0.855 per k for 1.5 watt. In the potential series Ta comes between platinum and silver, and is nearer to the latter; the modulus of elasticity is about equal to that of steel, the breaking strength of tantalum wire is 93 kg per millimeter diameter, calculated for cross section of 1 square-millimetre; the breaking strength rises as the cross section di-

minishes being 150—160 kg for a diameter of 0.05 mm. The extension is very small, 1—2 % before breaking according to the quality of the material. Nevertheless the metal may be drawn out to fine wire 0.03 mm in diameter. A lump of tantalum made red hot and placed under a steam hammer is at once flattened to foil which after repeated heating and hammering becomes as hard as diamond. An attempt to perforate a sheet of this kind 1 mm in thickness with a diamond drill after three day's uninterrupted drilling at 5000 revolutions per minute resulted in the formation of a hole about $\frac{1}{4}$ mm in depth, the diamond drill itself being much worn during the process. It was impossible to perforate the sheet completely, nevertheless it could be rolled out still thinner, while retaining its toughness and hardness. This property makes it valuable for tools such as drills, lathe tools, pen-nibs, &c.

Tantalum readily combines with hydrogen, the latter being so firmly fixed, that even on melting it is only partly removed. Red hot tantalum powder thrown into water decomposes the latter, the hydrogen igniting and shooting up in long flames. Larger pieces of tantalum when heated in air are little affected; they turn yellow at 400° and finally become covered with a fine layer of pentoxide; thin wire glows in air and oxygen without burning. Tantalum wire heated in nitrogen absorbs the gas and becomes dull and brittle. When heated with sulphur, selenium or tellurium under a layer of potassium chloride, Ta reacts forming dark-coloured substances.

Tantalum hardens iron like vanadium. Alloys with molybdenum and tungsten are elastic if they contain less than 5 % tantalum, brittle and hard with more than 5 %. Tantalum does not form alloys with silver or mercury.

Traces of carbon, boron and silicon make tantalum harder without affecting its elasticity; more than 1 % makes it brittle so that it can not be drawn into wire.

Tantalum is very resistant to the action of all acids; even hydrofluoric acid has only a slow action; when tantalum wire is dipped into hydrofluoric acid and then brought into contact with platinum (a platinum crucible) it dissolves with evolution of hydrogen and absorption of the gas, so that it becomes brittle.

Aqueous solutions of caustic soda and potash have no action even on heating; with fused alkali it forms crystalline masses.

Tantalum lamps. Tantalum (q. v.) in the form of very thin wire 0.05 mm in thickness has been used to make electric incandescent lamps. The new SIEMENS tantalum lamp makes use of the well known glass bulb of the old carbon lamp. These globes contain 2 stars with 11 and 12 points respectively mounted on a small rod at a distance of about 4—5 cm apart. The fine tantalum wire, about 50 cm in length is drawn between the points of these stars and is brought by the current to a temperature far beyond 2000° C, probably very close to the melting point. The carbon filament of the old lamp would fall to dust at this temperature, while the tantalum thread emits a mild reddish light.

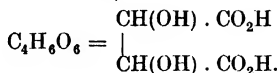
The advantage of the new lamp is that it uses half the current for the same amount of light as the carbon lamp. While the carbon lamp used 3 watt per standard candle the tantalum lamp requires only 1.5 watt. The economy of the new lamp is therefore the same as that of the NERNST lamp. While the latter, however, necessitates previous heating, the tantalum lamp works without help, lighting as soon as the current passes.

The price is relatively small, having fallen from 4 shillings to nearly half that amount.

A tantalum lamp may be screwed into the fitting of any carbon lamp: it burns in any position; after burning 600—1000 hours the current required rises from 1.5 to 2.1 watt per candle. The power of each lamp is 2.5 candle power.

Tartaline. An English substitute for tartaric acid for industrial purposes; it consists of potassium bisulphate.

Tartaric acid (dioxysuccinic acid).



The only acid of commercial importance is dextro-tartaric acid. Tartaric acid is always obtained from wine residues, generally from argol, sometimes from wine yeast and lees. The crude tartar (see "CREAM OF TARTAR") is a mixture of acid potassium tartrate and calcium tartrate. It is coarsely ground and heated by steam with ten times the quantity of H_2O to boiling point with the addition of crude HCl . The tartaric acid is then precipitated with lime water as calcium tartrate. The precipitate is filtered, washed with water and dried. The calcium tartrate so obtained, which is a commercial product, is then decomposed with excess of H_2SO_4 , the solution filtered from CaSO_4 and evaporated on the water bath at $70-80^\circ$. A higher temperature would cause charring of the tartaric acid by the H_2SO_4 . When a strength of 30°Bé is reached, the CaSO_4 which has separated is removed and the solution further concentrated in pans or vacuum apparatus to 43°Bé . The solution is then allowed to run into crystallizing vessels, and after 8 days the mother liquor is drawn off from the tartaric acid crystals. The mother liquor is again evaporated and crystallized and the process repeated so long as any tartaric acid is present.

The acid so obtained is dissolved, decolourized with animal charcoal, evaporated to 36°Bé and placed aside to crystallize. This process of decolourizing and recrystallization is sometimes repeated several times.

From the lees obtained in the manufacture of wine, brandy and oil of grapes are obtained by distillation. The residue is pressed and dried and in this form is brought into the market. It contains potassium bitartrate and calcium tartrate. To obtain tartaric acid this residue is boiled with H_2O under a pressure of 4–5 atm. and the solution decomposed in the way given above with lime water and then further treated. The residue from this process is finally boiled with water and H_2SO_4 for 3–4 hours, when the tartaric acid is set free and passes into solution. From the filtrate thus obtained calcium tartrate is precipitated by chalk and the further treatment carried out as given above.

According to Engl. Pat. 11991 (1904) for obtaining pure tartaric acid, the crude material, consisting of lees, crude argol, calcium tartrate, &c. is heated to $150-200^\circ \text{C}$, when the colouring matters present are destroyed and the mineral impurities are rendered partially insoluble. The material, which is broken up, is spread out on gratings and brought to a constant temperature by currents of indifferent gases (e. g. CO_2). The substance is then dissolved in dilute HCl , filtered, and the tartaric acid precipitated as calcium tartrate. It is then washed and treated with H_2SO_4 , and finally the precipitated CaSO_4 is filtered off. Pure tartaric acid forms large clear, odourless crystals with a pleasant acid taste. M. P. 135° . It dissolves in 1.8 parts of cold water. It dissolves very readily in hot water or alcohol but not at all in ether. It is used as a mordant in dyeing and printing. It is also used for making lemonade and other effervescent beverages. Tartaric acid is also often given as a medicine; it is valuable in photography, &c.

TEST. The commercial acid contains traces of Fe, Pb, Ca and H_2SO_4 . To test for these impurities 3 g of tartaric acid are dissolved in H_2O and the solution treated with excess of NH_3 saturated with sulphuretted hydrogen water, the ammoniacal solution treated with ammonium oxalate, the solution acidified with HNO_3 with AgNO_3 , and the neutral solution with BaCl_2 .

The amount of tartaric acid is determined by titration with normal alkali. On being heated to red heat the acid should leave no appreciable residue.

Tar and Tar products. For details see the articles on "BROWN COAL TAR", "WOOD TAR" and "COAL TAR".

Tar and Tar products:

Brotherton & Co., City Chambers, Leeds.

Tar products:

Forbes, Abbott & Lennard Ltd., 109 Queen Victoria St., London E.G.

Rectifying apparatus for Tar products:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Coal tar manufacturing apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Tar dyestuffs (Aniline dyestuffs, alizarine dyestuffs, &c.). The treatment of these substances is, in the present volume, subdivided as follows:—

Amidotriphenylmethane dyestuffs.

Oxytriphenylmethane dyestuffs.

Diphenylnaphthyl dyestuffs.

Azo dyestuffs.

Diazo dyestuffs.

Triazo dyestuffs.

Tetrazo dyestuffs.

Nitro dyestuffs.

Nitroso dyestuffs.

Indophenols.

Oxyketone dyestuffs.

Acridine dyestuffs.

Azoxy dyestuffs.

Diazoamido dyestuffs.

Pyronine dyestuffs.

Quinoline dyestuffs.

Oxazines and Thiazines.

Indigo dyestuffs.

Thiobenzenyl dyestuffs.

Pyrazolone dyestuffs.

Azine dyestuffs (Safranines and Indulines separately).

Sulphur dyestuffs.

Fuchsine, Alizarine, Methylene blue and Tartrazine, also Cachou de Laval, Thiocratechium, Urania blue, Ursol, Nigramine, Nigrisine, Aniline black, Chromogene and Indamines are treated separately. The individual dyestuffs are not enumerated in the respective groups.

Apparatus for manufacture of tar colours.

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Tar oils (see "WOOD TAR" and "COAL TAR"). A separation of the heavy oils is not carried out commercially on a large scale. The mixture, as it is, is used to produce oil gas, for carburetting lighting gas, for the manufacture of lamp black, as a disinfectant and in producing the latter (Creoline, Lysol, Sanogen, &c.), in softening pitch, impregnating wood, for washing textiles, &c. The water-soluble or at least emulsifying tar oils are coming into favour for the purposes enumerated. Tar oils are made water-soluble by sulphonating,

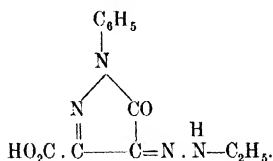
emulsified by the aid of soaps &c.; see the article on "OILS" and "MINERAL OILS". The latter article also gives methods of rendering tar oils odourless.

Tar oils:

Brotherton & Co. Ltd., City Chambers, Leeds.

Tartar emetic (Potassium antimony tartrate) see "ANTIMONY COMPOUNDS".

Tartrazine. A coal-tar dyestuff obtained by the action of 2 mol. p-phenylhydrazinemonosulphonic acid on 1 mol. dioxytartaric acid when the two components are heated in acid solution. According to recent investigations tartrazine is a pyrazolone like antipyrine (q. v.) with the following constitution:



It is sold in the form of its Na-salt. An orange coloured powder producing in an acid bath a golden shade on wool and silk which is very fast to light.

Tellurium. Te. A. W. = 125.3. Rare element closely allied to sulphur, and still more closely to selenium. Tellurium and its compounds have no practical value.

Terebene. Turpentine oil is gradually mixed with 5 % concentrated H_2SO_4 and after some time distilled in steam. The distillate is washed with a dilute solution of Na_2CO_3 , separated, dehydrated with CaCl_2 and fractionally distilled, the parts passing over between 156° and 160°C being collected.

It is a mixture of various terpenes, is pale yellow and used as a substitute for turpentine.

Terpenes. Hydrocarbons of the general formula $\text{C}_{10}\text{H}_{16}$, but of very varying nature. They are present in essential oils, which sometimes consist merely of these. Terpenes oxidize readily and become partly resinous. They are generally subdivided into olefine terpenes, terpane group (or menthane group) and camphane group.

To the first group belong a number of hydrocarbons, alcohols, aldehydes and acids (open chain compounds) found in essential oils. It is generally easy to convert them into terpene-like or aromatic substances. Geraniol and linalol are olefine terpene alcohols; citronellal and citral are terpene aldehydes.

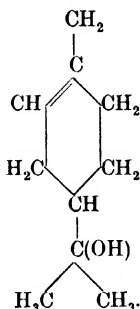
The members of the terpane group (menthane group) are six-membered closed ring compounds. The terpenes of this group can add on 4 monovalent atoms. Amongst the hydrocarbons of the terpane group are limonene, terpinene, and phellandrene; the alcohols include menthol, cineol, and terpineol, the ketones include, amongst others, carvone.

The members of the camphane group are also distinguished by a closed six-membered ring; they can only add on 2 monovalent atoms. Hydrocarbons belonging to the camphane group are camphene and the pinene of turpentine oils. The chief member of the alcohols of the camphane group is borneol (q. v.) while the most important of the camphane ketones is camphor itself.

See "BORNEOL", "CAMPHOR" and "PERFUMES, ARTIFICIAL", also "OILS, ESSENTIAL", "PEPPERMINT, OIL OF", &c.

Terpinene see "TERPENES".

Terpineol (Terpene hydrate). $C_{10}H_{17}OH$. A cyclic terpene alcohol of the constitution:



It is formed when 2 parts of French turpentine oil are allowed to stand for 12 hours with 1 part concentrated H_2SO_4 and 3 parts 90 % alcohol. The method of BERTRAM and WALBAUM (patented) is interesting. Five portions each of 200 g of rectified turpentine are added gradually to a mixture of 2 kg glacial acetic acid, 50 g H_2SO_4 and 50 g H_2O . The temperature is not allowed to rise above 50° . After standing for some hours the mixture is diluted with water and extracted with a solution of Na_2CO_3 . The product obtained, consisting of terpenes and terpene esters is purified by distillation with steam and then warmed with KOH solution when terpineol is formed. It is valued on account of its lilac-like odour. It is sold in the liquid and also in the crystalline form; the liquid product has the stronger odour.

Terra di Siena see "MINERAL COLOURS".

Tetra-Isol. A preparation of carbon tetrachloride completely soluble in water. It is used as a cleaning agent in the textile industry.

Tetrazo-dyestuffs. A class of dyestuffs containing four azo-groups $-N=N-$. See "AZODYES", "DIAZODYES" and "TRIAZODYES".

Tetrazodyestuffs may be obtained by the condensation of 2 mon-amines with 1 di-amine or by the condensation of 2 diamines. So for instance Hessian brown BB (sodium salt of benzidinediazodisulphonic acid, azoresorcin) is obtained by condensing resorcline with sulphanilic acid, and the subsequent condensation of 2 molecules of the product with 1 mol. benzidine as follows:

 / Sulphanilic acid

Resorcline

 > Benzidine

Resorcline

 \ Sulphanilic acid.

A tetrazo dyestuff formed from 2 diamines is azoorange R:

 / Naphthionic acid

Toluidine

 > Dioxidiphenylmethane

Toluidine

 \ Naphthionic acid.

All tetrazodyestuffs dye cotton without a mordant.

Textile fibres. The fibres used for making woven goods, ropes, sail cloth, &c., &c. are divided into "VEGETABLE FIBRES" and "ANIMAL FIBRES" (q. v.).

The various textile fibres may be distinguished by the following reactions:

I. Distinctions between Animal and Vegetable fibres.

	Animal fibres	Vegetable fibres
Burning.	Smell of burnt horn; alkaline vapours; when removed from the flame they no longer burn.	Burn rapidly, even when removed from the flame, empyreumatic odour; acid vapours.
Soda lye of 8% (S. G. 1.05 = 6.7° Bé).	Dissolve when warmed. Solution of wool turned violet by sodium nitroprusside; black precip. with an alkaline solution of a lead salt.	Scarcely affected.
Conc. Nitric acid.	Turn yellow on heating.	Remain colourless.
Nitrating acid (equal vols. conc. HNO_3 and H_2SO_4).	Silk is dissolved; wool becomes yellow or brown.	Colour and structure unaltered; very inflammable after drying.
Zinc chloride solution 60° Bé.	Silk dissolves, at 100°, is precipitated again by water; wool unaffected.	No effect.
Ammoniacal solution of copper oxide.	Silk is dissolved but not wool.	Flax, hemp, cotton are gradually dissolved.
Rosaniline solution decolorized by ammonia.	After warming, and washing away the free alkali: Red colour.	No effect when heated similarly.
Alcoholic solution of α -Naphthol (20%).	The sample is mixed with a little water, a few drops of the solution and concentrated sulphuric acid. The liquid turns yellow; silk dissolves.	Dark violet colour; the fibre dissolves.

II. Special reaction of the Vegetable textile fibres.

	Cotton	Flax	Hemp	Jute	Muslin	Manila-Hemp	New Zealand Flax	Aloë	Cocoa Nut
Zinc Chloride iodide	violet	violet	violet	brownish-yellow	dirty violet	brown yellow to dirty violet	golden yellow	golden brown yellow	golden to brown yellow
Iodine + H_2SO_4	blue	blue	blue	greenish blue	dirty blue	—	greenish-blue	yellow, green towards outside	—
Ammoniacal solution of CuO	blue solution	blue solution	blue solution	blue solution	blue solution	—	bluish	bluish, fibre swells	—

	Cotton	Flax	Hemp	Jute	Muslin	Manila-Hemp	New Zealand Flax	Aloë	Cocoa Nut
Aniline sulphate solution	—	—	often pale yellow	golden yellow	—	yellow	yellowish	yellowish	beautiful yellow
Phloroglucine solution	—	—	often violet red	intense red	—	red	pale red	pale red	pale purple-red

III. Table for examining all textile fibres.

10% potash lye or soda lye is allowed to act the on the mixed fibres:								
part dissolves		part remains undissolved			all dissolves			
It is then subjected to the action of ZnCl_2								
all dissolves	part dissolves	nothing dissolves	nothing dissolves		partially dissolves	nothing dissolves		
The alkaline solution does not turn black on addition of lead acetate: <i>Silk</i> .	The soluble part does not turn black with lead acetate, the insoluble part does: <i>Silk</i> and <i>Wool</i> .	The whole becomes black with lead acetate: <i>Wool</i> .	Chlorine water and also ammonia colour the fibres:		Part becomes when treated with lead acetate:	Nitric acid turns part yellow, rest remains white: Mixture of <i>Flax</i> and <i>Cotton</i> .		
			red-dish-brown	has no effect				
			The fibre becomes red with fuming nitric acid: <i>New Zealand flax</i> .	Alcoholic solution of fuchsin colours the fibre:			black	not black
				permanently	not fast to washing		Potash lye partly dissolves the fibre insoluble in zinc chloride. The remaining fibres dissolve in ammoniacal copper oxide: Mixture of <i>Wool</i> , <i>Silk</i> and <i>Cotton</i> .	Picric acid turns part yellow; rest remains white: <i>Silk</i> and <i>Cotton</i> .
				Potash lye dyes yellow	Potash lye does not dye yellow: <i>Cotton</i> .			
				Iodine and H_2SO_4 dye.				
	yelow: <i>Hemp</i>	blue: <i>Flax</i>						

The reagents mentioned are prepared as follows:

1. IODINE ZINC CHLORIDE: 100 parts ZnCl_2 -solution (S. G. 1.8), 12 parts H_2O , 6 parts KI and then I until iodine vapours are given off. Should be kept in the dark.

2. IODINE and SULPHURIC ACID: A few scales of I are ground with a few drops of alcohol giving a brown solution. H_2O is then added until the colour is a pale wine yellow. The materials are sprinkled with dilute H_2SO_4 (1 part concentrated H_2SO_4 + 2 parts H_2O) and then with the iodine solution.

3. AMMONIACAL SOLUTION OF COPPER OXIDE: $CuCO_3$ is precipitated from a $CuSO_4$ solution with $NaCO_3$ solution, filtered, the precipitate carefully washed with H_2O , and NH_3 (S. G. 0.91) added, though not enough to dissolve the whole. It is shaken several times, allowed to settle and the supernatant blue liquid used as the reagent.

4. ANILINE SULPHATE: To be used in 1% aqueous solution.

5. PHLOROGLUCINE: To be used in $\frac{1}{2}$ % aqueous solution.

PINCHON recommends the following method of investigating mixed textiles: (Table see p. 698.)

Testing apparatus for textile fibres:

Carl Zeiss, Jena (Germany).

Thallium. Tl. A. W. = 204.2. A rare element allied to silver, and the alkali metals. From another point of view it may be classed with lead; as a rule it is included in the aluminium group.

Thallium is crystalline, as soft as tin and may be readily cut; it oxidizes readily in the air and is therefore generally kept under water. S. G. 11.9; M. P. 270°; B. P. at white heat.

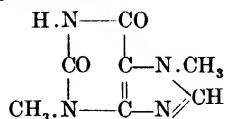
Neither thallium nor its compounds are of great industrial value.

Thebaine see "OPIUM AND OPIUM ALKALOIDS".

Theine see "CAFFEINE".

Thenard's blue see "COBALT COLOURS".

Theobromine = Dimethylxanthine:



The active principle of the cocoa bean, related to caffeine (q. v.). Cocoa beans contain about 1.5 %, cocoa husk about 0.3 % of theobromine.

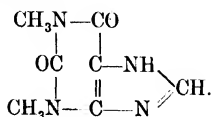
According to DRAGENDORFF cocoa husks are boiled with H_2O , pressed and the liquid precipitated with lead acetate, filtered; the lead removed by H_2S , the solution dehydrated with calcined magnesia and the powdered residue boiled with alcohol. When the filtrate is cold part of the theobromine separates; the rest is obtained by distilling off the alcohol and recrystallizing. — Instead of using cocoa husks cocoa powder free from oil may be used. It is mixed with half its weight of slaked lime and extracted several times with 80 % alcohol. The alcoholic extract is treated as above.

Colourless, odourless crystalline powder, with a bitter taste which slowly develops; it sublimes at 290—295° C without melting or without decomposition. 1 part theobromine dissolves in 1700 parts cold or 150 parts hot H_2O ; in 4300 parts cold or 430 parts hot absolute alcohol, much more readily in aqueous alcohol.

In consequence of its small solubility it was formerly but little used in medicine. An easily soluble salt, theobromine sodium salicylate has been discovered which is an important drug. See "DIURETINE".

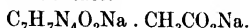
THEOCINE.

Theocine (Theophylline) = 1.3-dimethylxanthine. The constitution given by the following formula:



It is obtained by various methods, e. g. from cyanacetic acid.

Theocine is an excellent diuretic, especially in the form of its easily soluble double salt sodium theocine acetate.



Dose 0.3—0.5 g, twice to three times a day.

Theophylline. Another name for Theocine (q. v.).

Thermiol. A 25 % solution of sodium phenylpropionate recommended for inhalation in cases of laryngitis and lung troubles.

Thermite. A mixture of powdered aluminium and metallic oxides, e. g. iron oxide, manganese oxide, chromium oxide, &c. When ignited these mixtures continue to burn giving a temperature of 2000—3000° C. This method of obtaining high temperatures is called aluminothermy. The great quantities of thermic energy (the heat of combustion of Al is 7140 calories, and is greater than that of any other metal) can thus be used in the simplest way (without extensive machinery and apparatus). In aluminothermy the Al is converted into corundum while the metallic oxide is reduced to the respective metal.

As the burning of Al, i. e. the lighting of the mixture called thermite, necessitates a high initial temperature, an igniting mixture is first placed over it; this is a mixture of barium peroxide and aluminium or better still magnesium filings. The inflammable mixture is ignited with a wind fuse whereupon the reaction sets in, spreading from the point of ignition, so that by adding more thermite the process may be continued, i. e. the heat be utilized for any length of time. Previous external heating is unnecessary.

Aluminothermy is used in welding rails and pipes, repairing faulty steel castings, in preparing metals (free from carbon), e. g. chromium, manganese, nickel, cobalt, &c., further in producing artificial corundum used as emery, as well as a material for fireproof crucibles, moulds, stones, &c. Quite recently thermite has been used as an addition to molten cast iron and steel in order to obtain castings free from bubbles.

The whole process is protected by patent.

For the so-called thermite explosives (aluminium explosives) see "SAFETY EXPLOSIVES".

Thermochemistry see "FUELS" and "CALORIMETRY".

Thermometry. Calculation of thermometer degrees centigrade Celsius (C), Reaumur (R) and Fahrenheit (F) in terms of each other:

$$x^\circ \text{C} = \frac{4}{5} x^\circ \text{R.} \qquad x^\circ \text{R} = \frac{5}{4} x^\circ \text{C.}$$

In expressing centigrade degrees in terms of Reaumur and *vice versa* the sign remains unchanged.

$$x^\circ \text{C} = \left(\frac{9}{5} x + 32 \right)^\circ \text{F.} \qquad x^\circ \text{R} = \left(\frac{9}{4} x + 32 \right)^\circ \text{F.}$$

$$x^{\circ} \text{F} = (x - 32) \cdot \frac{5}{9}^{\circ} \text{C}.$$

$$x^{\circ} \text{F} = (x - 32) \frac{4}{9}^{\circ} \text{R}.$$

CORRECTION OF THERMOMETER DEGREES:

If T denote the temperature indicated by the thermometer and N the length of exposed stem, expressed in degrees, and t the temperature of the mercury at the point $T - \frac{1}{2} N$, then the degrees given in the following table are added to T. The table is based on the formula: $T = 0.000154 N (T - t)$, as 0.000154 is the difference of the cubical coefficients of expansion of mercury and glass.

N.	T-t = 10°	20°	40°	50°	60°	80°	100°	120°
10	0.02	0.03	0.06	0.08	0.09	0.12	0.15	0.18
20	0.03	0.06	0.12	0.15	0.18	0.25	0.31	0.37
40	0.06	0.12	0.25	0.31	0.37	0.50	0.62	0.74
60	0.09	0.18	0.37	0.46	0.56	0.74	0.92	1.11
80	0.12	0.25	0.50	0.62	0.74	0.99	1.23	1.48
100	0.15	0.31	0.62	0.77	0.92	1.23	1.54	1.85
120	0.18	0.37	0.74	0.92	1.11	1.48	1.85	2.26
140	0.22	0.43	0.86	1.08	1.39	1.72	2.16	2.59
160	0.25	0.49	0.99	1.23	1.48	1.97	2.46	2.96
180	0.28	0.56	1.11	1.39	1.66	2.22	2.77	3.33
200	0.31	0.62	1.23	1.54	1.85	2.46	3.08	3.70

Thermostat see "BACTERIOLOGY".

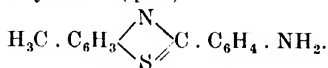
Thermometers:

W. Niehls, Berlin SW. 48.

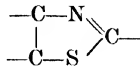
Thiazol dyestuffs see "DIAZOAMIDO DYESTUFFS" and "THIOBENZENYL DYESTUFFS".

Thigenol. A concentrated sodium compound of oleine sulphonic acid in which 10 % of the sulphur is organically combined. Thick odourless liquid used in skin diseases, &c.

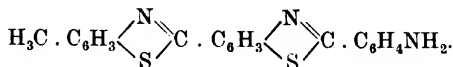
Thiobenzeryl dyestuffs. A class of dyestuffs of which the members, like those of the diazodyestuffs (q. v.) are derived from dehydrothiotoluidine



They are frequently combined with the group of thiazol dyestuffs as they all contain the thiazol ring



Dehydrothiotoluidine is obtained by heating p-toluidine with sulphur; when the reaction is continued for some time primuline is formed. It is obtained by heating 2 mol. p-toluidine with 5 atoms sulphur to 250—280°C and sulphonating the resulting primuline base with fuming H_2SO_4 . Primuline is the sodium salt of the sulphonic acid of a base which apparently has the following constitution:



Non-mordanted cotton is dyed yellow by primuline in neutral solution. For other colours see "INGRAIN DYESTUFFS".

The other thiobenzyl dyestuffs are homologues of dehydro-thio-toluidine and primuline.

Thiobenzyl dyestuffs are true thiazol derivatives; they are all yellow. The thioflavines and chloramine yellow belong to this group.

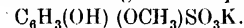
In the diazoamido dyestuffs the chromogen character of the thiazol is less pronounced, though at the same time they cannot be regarded as true azo-substances.

Most thiobenzyl dyestuffs are like primuline used on cotton, without mordants.

Thiocatechine. A coal-tar dye of unknown constitution, obtained by melting p-diamines or acetyl-nitramines with S and Na_2S , dissolving the melt in H_2O and precipitating the dye by adding acid (when H_2S is evolved). Thiocatechine therefore is a sulphur dye (q. v.). By purifying the dye and dissolving in alkali sulphite thiocatechine S is prepared.

It is used to dye browns on cotton; the dyeing is carried out with the addition of NaCl and Na_2CO_3 and development with potassium bichromate and sulphuric acid.

Thiocol = the potassium salt of o-guaiacolsulphonic acid.



Colourless crystalline powder, very easily soluble in H_2O . Ordered as a non-poisonous substitute for guaiacol in tuberculosis of the lungs.

Thio-cyanates see "SULPHOCYANIDES".

Thioform = bismuth dithiosalicylate. Obtained by digesting 1 mol. sodium dithiosalicylate Na with 4 mol. neutral bismuth nitrate in presence of caustic soda.

Yellowish odourless powder, insoluble in H_2O , used externally in place of iodoform and taken internally for stomachic and intestinal catarrh.

Thiol. A product very similar to ICHTHYOL (q. v.).

It is prepared by sulphonating gas oil (brown-coal tar-oil) with sulphur, treating the reaction product with strong H_2SO_4 and pouring the whole into water. The thiol is then purified in various ways. It is sold in the solid form (*thiolum siccum*) as well as in concentrated aqueous solution (*thiolum liquidum*).

It is used medicinally in the same way as ichthyol (q. v.).

Thionyl chloride see "CHLORINE COMPOUNDS".

Thiosinamine (Alkyl thiourea). $\text{NH}_2 \cdot \text{CS} \cdot \text{NHC}_3\text{H}_5$. Obtained from mustard oil $\text{CS} : \text{NC}_3\text{H}_5$ by the action of NH_3 .

Crystals M. P. 74° , readily soluble in alcohol and ether, less so in H_2O . It is used medicinally for softening scars. See "FIBROLYSINE".

Thiosulphates. The salts of thiosulphurous acid are better called thiosulphates and not hyposulphites, since apart from the errors caused by misunderstanding, it has been recognized that SO_2 may be reduced to hydro-sulphurous acid (see "HYDROSULPHITES").

The thiosulphates will be found under the respective metallic compounds.

Thomas phosphate see "SLAGS" and "MANURES, ARTIFICIAL".

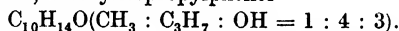
Thorium and Thorium compounds. Thorium. Th. A. W. = 232.5. Until recently the element itself was of no industrial importance. At present, however, SIEMENS and HALSKE have taken out several patents for the production of thorium metal: According to Germ. Pat. 133958 Th is obtained by deating thorium nitride (prepared by the action of NH_3 -gas on various thorium compounds at a red heat) avoiding all oxidizing actions. According to Germ. Pat. 133959 the vapours of Na are allowed to act on vapours of volatile organic thorium compounds; in this manner substances may be covered with metallic thorium (e. g. a carbon filament *in vacuo*). Germ. Pat. 146503 treats of the purification of thorium.

Thorium compounds are of special importance:

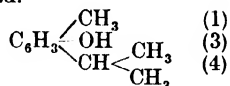
They are of the greatest value for lighting purposes with incandescent gas light as the mantles usually consist of a mixture of 99 % thorium dioxide ThO_2 with 1 % cerium oxide CeO_2 .

Thorium compounds, which are very like those of zirconium (q. v.), are almost exclusively prepared from monazite which is a cerium-thorium phosphate. In impregnating mantles (see "INCANDESCENT GAS LIGHT") various thorium salts are used which are converted into oxides when heated; the salt generally used is thorium nitrate $\text{Th}(\text{NO}_3)_4$; it crystallizes with $6 \text{H}_2\text{O}$ and is soluble in water.

Thyme, oil of, and Thymol. Oil of thyme is obtained from the fresh, flowering plant *Thymus vulgaris* by distillation with water. The most important constituent is THYMOL: thymene and cymene are also present. Thymol is a homologue of phenol, methylisopropylphenol



Formerly oil of thyme was used medicinally as an antiseptic, but now the pure thymol is used instead.



On a large scale thymol is obtained from the seeds of the Indian Ajowan. The oil obtained by distillation with water is shaken with NaOH , the dissolved thymol separated from the undissolved matter, precipitated with mineral acids and purified. It is generally obtained by strongly cooling, the oil when the thymol crystallizes out. Synthetically it may be obtained from o-brom-p-cymene. This is converted by treatment with fuming H_2SO_4 into cymene 2 brom 5 sulphonic acid, which is recrystallized and then treated with zinc dust and NH_3 under pressure. The cymene sulphonic acid thus obtained is converted into thymol by fusing with KOH .

Large colourless crystals with an aromatic taste and an odour like that of thyme. M. P. 50° ; B. P. 231.8° . It dissolves in 1100 parts of water, readily in alcohol, ether and chloroform. It is readily volatile in steam.

Tin. Sn. A. W. = 119.1. It occurs principally as tin stone, SnO_2 . The ore is first crushed, freed from gangue and then roasted in revolving furnaces to remove As and S. It is then washed with water (*elutriation*) or with HCl to remove Cu, Fe and Bi. The oxide is then reduced by heating with wood charcoal in blast furnaces or reverberatory furnaces.

Tin is refined by liquation, i. e. it is placed on sloping hearths and heated until it just melts. The pure tin flows into receptacles leaving behind the impurities. It is then again melted and stirred with poles of green wood. In this way all easily oxidized metals separate as a scum on the surface. BANCA tin was formerly considered to be the best, but now Straits Settlement and Australian tin are reckoned better.

Tin is obtained from the tin slags (Germ. Pat. 146965) by a wet process. The ground slag is extracted with a mixture of H_2SO_4 and HCl in the proportion 2 : 1, or in place of the HCl soluble chlorides may be used. The metal is obtained from the solution electrolytically.

Recently tin has been obtained from tinned articles; three methods are in use, mechanical, chemical and electrolytical. By the first method, which gives the worst results, the tin is removed by heating or melting.

In the chemical process the tin is recovered from the scrap by treatment with a mixture of dilute acids ($\text{HCl} + \text{HNO}_3$ or H_2SO_4) and precipitation with zinc. Other solvents have been used with more or less success.

The electrolytical method for stripping tin from tinned goods is much more important. The electrolyte is usually a solution of caustic soda (6—7 % Na_2O); the anode is formed by the scrap tin placed in wire baskets and the cathode is either the iron sides of the bath or an iron sheet dipping into the bath. The voltage should be about 1.5, when the tin is precipitated in a spongy state.

In other processes acid electrolytes are used. E. g. in the old SIEMENS-HALSKE process the electrolyte was 1 vol. 60 % H_2SO_4 and 9 vol. H_2O , the anode was a box made of wooden gratings packed with the scrap tin, and the cathodes were of copper. Current 100 amp. per square-metre. Recently SIEMENS and HALSKE have adopted the alkaline electrolyte as giving better results.

Engl. Pat. 8759 (1902) uses a solution of ferric sulphate as electrolyte. According to Germ. Pat. 152989 a chemically pure and crystalline product is obtained by using a solution of ZnCl_2 as electrolyte to which NH_4Cl is added (more than suffices to form $\text{SnCl}_4 \cdot 2 \text{NH}_4\text{Cl}$). Organic acids are also added to neutralize the NH_3 set free and to bring into solution any foreign metals present. Acetic acid forms lead acetate which is converted into white lead by the CO_2 simultaneously evolved. The temperature of the bath must not be lower than 50° .

According to Germ. Pat. 142333 the stripping is carried out electrolytically, using a carbon electrode in an alkaline bath.

Tin is an almost silver-white, shining metal, M. P. 233° ; B. P. 1500° . S. G. of tin (fused and then allowed to solidify) is 7.29 (at 15°). At the ordinary temperatures it is soft and ductile and can be rolled out into sheets. At 200° it is hard and brittle. If cooled to -40° it is converted into a modification, grey tin, which is a powder S. G. about 5.8. Fused tin solidifies in a crystalline form and if a bar of tin be bent a curious sound is emitted, due to the rubbing together of the crystals. At ordinary temperatures tin is unaffected by air or water. When fused it becomes coated with a grey film and is gradually converted into tin oxide. It dissolves in warm KOH and HCl and in cold diluted HNO_3 . Concentrated HNO_3 changes it to metastannic acid.

Tin is used for the manufacture of apparatus, vessels, &c., for covering other metals, for soldering, for mirrors, for alloys, &c.

Tin alloys see ANTIMONY ALLOYS, LEAD ALLOYS, BRONZES, &c.

Phosphor tin is an alloy obtained by dissolving 5—10 % P in molten tin. It is used in the preparation of copper alloys.

Tin colours.

1. MOSAIC GOLD (tin disulphide). SnS_2 . It may be obtained by wet methods, by precipitating SnCl_4 solution with H_2S , though a fine gold-like shade can only be attained by dry processes. Finely-powdered tin or better still, tin amalgam is heated with NH_4Cl and S. For instance 1 part Hg is mixed with 2 parts molten Sn and a mixture of 18 parts of this amalgam with 7 parts S and 6 parts NH_4Cl is heated in retorts; NH_4Cl first sublimes,

and then HgS, the disulphide remaining behind. It forms small, fine, golden-yellow scales subliming without decomposition. It is used in gilding mirror frames, though now to a large extent replaced by bronze colours.

2. PINK. A chromium-tin compound becoming bright red in the oxidizing flame; much used in ceramics as a sub-glazing colour. It is also used, though more rarely, as a painters' colour and for printing.

1 kg Sn is converted into SnO_2 by treatment with HNO_3 , a solution of 50 g $\text{K}_2\text{Cr}_2\text{O}_7$ in 1 litre water is added, then 2 kg chalk and 1 kg ground quartz sand. The whole is dried, crushed and then heated for several hours in strong Hessian crucibles. This substance (chromium oxide — tin oxide) which is rose pink, is ground, then heated again (best with the addition of a little calcined Na_2CO_3), ground moist and dried. As a porcelain colour it may be used after the first heating.

3. PURPLE OF CASSIUS, see "GOLD COLOURS".

Tin compounds. There are stannous compounds, stannic compounds and stannates, i. e. salts in which tin oxide plays the part of an acid.

1. AMMONIUM STANNIC CHLORIDE (Pink salt). $\text{SnCl}_4 \cdot 2 \text{NH}_4\text{Cl}$. Two parts tin salts (see No. 8 "STANNOUS CHLORIDE") are dissolved in H_2O , the solution saturated with chlorine gas and then poured into a hot solution of 1 part ammonium chloride in 2 parts H_2O . The colourless pink salt separating dissolves in 3 parts H_2O . The concentrated solution remains unchanged on boiling, while the dilute solution under the same treatment decomposes with separation of metastannic acid. Pink salt is chiefly used instead of the strong caustic stannic chloride (as a mordant in dyeing).

2. PINK SALT, see No. 1 "AMMONIUM STANNIC CHLORIDE".

3. PREPARING SALT (Sodium stannate), see No. 34 "SODIUM COMPOUNDS".

4. ROSE SALT (Physic. tin composition). Produced by dissolving Sn in mixtures of HCl and HNO_3 , sometimes also in mixtures of HCl and H_2SO_4 ; in the first case it consists chiefly of SnCl_4 , in the latter SnCl_2 . Besides this the viscous yellow liquid contains stannous nitrate, metastannic acid, and ammonium nitrate in varying proportions. Used as a mordant in dyeing, formerly more than now.

5. SODIUM STANNATE, see No. 34 "SODIUM COMPOUNDS".

6. STANNOUS ACETATE. Obtained by dissolving freshly precipitated stannous hydroxide in dilute acetic acid. Used as mordant in cotton printing.

S. G. and contents of stannic chloride solutions at 15°C
(GERLACH).

S. G.	$\text{SnCl}_4 + 5\text{H}_2\text{O}$ %	S. G.	$\text{SnCl}_4 + 5\text{H}_2\text{O}$ %	S. G.	$\text{SnCl}_4 + 5\text{H}_2\text{O}$ %
1.012	2	1.2268	34	1.538	66
1.024	4	1.242	36	1.563	68
1.036	6	1.259	38	1.587	70
1.048	8	1.2755	40	1.614	72
1.059	10	1.293	42	1.641	74
1.072	12	1.310	44	1.669	76
1.084	14	1.329	46	1.698	78
1.097	16	1.347	48	1.727	80
1.110	18	1.366	50	1.759	82
1.1236	20	1.386	52	1.791	84
1.137	22	1.406	54	1.824	86
1.151	24	1.426	56	1.859	88
1.165	26	1.447	58	1.893	90
1.180	28	1.468	60	1.932	92
1.195	30	1.491	62	1.969	94
1.210	32	1.514	64	1.988	96

A solution of SnCl_2 with sodium acetate is known by the same name, though also called tin mordant.

7. STANNIC CHLORIDE. SnCl_4 . Obtained by dissolving tin oxide in HCl and evaporating, or by the action of Cl (or nitrohydrochloric acid) on SnCl_2 ; in the anhydrous condition it is obtained by heating tinned iron scraps, &c. in a current of chlorine, when Fe remains while SnCl_4 sublimes. When concentrated solutions are evaporated — either in the air or *in vacuo* — opaque deliquescent crystals, $\text{SnCl}_4 + 5 \text{H}_2\text{O}$ are obtained. When dilute solutions are heated they precipitate metastannic acid, a property which is used in dyeing silk (to increase its weight). It is also used as a mordant in dyeing (see "WOOL DYEING") and in tin plating. It is sold liquid or as a deliquescent salt.

8. STANNOUS CHLORIDE (Tin salt). $\text{SnCl}_2 + 2 \text{H}_2\text{O}$. Obtained by dissolving tin filings in HCl and evaporating with addition of granulated Sn . As it decomposes slightly on heating it is dried by centrifuging. It forms white crystals with $2 \text{H}_2\text{O}$, is easily soluble in H_2O and alcohol. From the aqueous solution basic salt is soon precipitated. This may be prevented by adding tartaric acid. It is used in dyeing as a mordant, for reducing indigo, in preparing purple of Cassius (see "GOLD COLOURS") in tin plating, &c.

S. G. and contents of stannous chloride solutions at 15°C (GERLACH).

S. G.	$\text{SnCl}_2 + 2 \text{H}_2\text{O}$ %	S. G.	$\text{SnCl}_2 + 2 \text{H}_2\text{O}$ %	S. G.	$\text{SnCl}_2 + 2 \text{H}_2\text{O}$ %
1.013	2	1.212	28	1.497	54
1.026	4	1.230	30	1.525	56
1.040	6	1.249	32	1.554	58
1.054	8	1.268	34	1.582	60
1.068	10	1.288	36	1.613	62
1.083	12	1.309	38	1.644	64
1.097	14	1.330	40	1.677	66
1.113	16	1.352	42	1.711	68
1.128	18	1.374	44	1.745	70
1.144	20	1.397	46	1.783	72
1.161	22	1.421	48	1.821	74
1.177	24	1.445	50	1.840	75
1.194	26	1.471	52		

9. TIN COMPOSITION, see No. 4.

10. STANNIC OXIDE. SnO_2 . Occurs naturally as tin stone. It may be obtained by strongly heating tin in the air. It is amorphous, white or yellow, not volatile, is not affected by concentrated acids, though dissolved by potash lye. It is used as a polish, in manufacturing milk glass, enamel and non-transparent glazes. — According to Amer. Pat. 780984 SnO_2 is obtained by passing hot air over molten Sn and removing the stannic oxide which forms on the surface.

By precipitating SnCl_4 -solution with NH_3 or Na_2CO_3 a white precipitate of stannic hydroxide (stannic acid) H_2SnO_4 or H_2SnO_3 is obtained. The precipitate is not quite insoluble in H_2O ; it dissolves readily in concentrated HCl , HNO_3 , H_2SO_4 and in dilute alkalis. Of the same constitution as stannic acid is metastannic acid, obtained by the action of concentrated HNO_3 on Sn and forming an insoluble powder. Both stannic acid and metastannic acid are converted into SnO_2 on heating.

Stannic oxide:

Willy Manger, Dresden, Germany.
Blücher.

Tin mordants.

1. **TIN SALT.** (stannous chloride). SnCl_2 . (For preparation, see "TIN COMPOUNDS"). It dissolves to a clear solution in little H_2O , and is precipitated on diluting as insoluble $\text{Sn}(\text{OH})\text{Cl}$, though not when free HCl is present. It is used as a wool mordant for cochineal scarlet, for dyeing blacks on silk and for weighting silk. For cotton it is only used with other mordants in order to alter the shade.

2. **STANNIC CHLORIDE.** SnCl_4 . (Preparation see "TIN COMPOUNDS".) It is used for weighting silk and as a mordant in dyeing cotton with dye woods (Logwood, Lima wood and fustic). In this case the cotton is first treated with tannic acid solution and then with stannic chloride solution; the tannic acid is merely to fix the stannic oxide, while the latter fixes the colouring matter of the wood.

3. **PINK SALT** (ammonium stannic chloride). ($\text{SnCl}_4 + 2 \text{NH}_4\text{Cl}$). For preparation, see "TIN COMPOUNDS". Application the same as stannic chloride.

4. **PREPARING SALT** (sodium stannate). $\text{Na}_2\text{SnO}_3 + 3 \text{H}_2\text{O}$. (Preparation, see No. 38 "SODIUM COMPOUNDS".) It is used for mordanting wool and cotton. The materials are soaked in a solution of the salt and then quickly passed through very dilute H_2SO_4 . In this process stannic hydroxide settles in the fibre and forms insoluble lakes with the dyes.

Tin plating. Tin plating sheet iron, i. e. the manufacture of tin plate is a very complicated process. The sheets are first very carefully dipped in a mixture of dilute H_2SO_4 and HCl , then well washed, dried, and finally packed in iron boxes and, gradually heated to cherry-red heat in furnaces. They remain at this temperature for six hours, are then slowly cooled, made smooth (cold treatment) between hard cast rollers, heated again rapidly with exclusion of air and dipped once more in a fermenting mixture of bran and water. Then follows another short dipping in dilute H_2SO_4 , washing, brushing with sand and immersion in fresh water. The sheets are now prepared for plating. They now pass successively through five vats; the first and last containing hot oil (palm oil), while the second is filled with ordinary molten tin at 400°C . The tin is covered with a layer of palm oil to prevent oxidation. The sheets are placed into the oil vessel while wet, after ten minutes they are moved to the first tin vat (coarse) where they remain for 10 minutes. From there they pass into the brush vat containing a better quality of tin at 240°C (not higher). About 20 sheets at a time are taken from the brush vat, laid out and brushed with long brushes soaked in oil; this operation effects the actual alloying of the Fe and Sn. The stripes caused by the brushing are removed in the last tin vat (fourth vessel) which contains the purest tin covered with a thin layer of palm oil. At last they pass into the fifth vessel, filled with palm oil at about $200\text{--}400^\circ \text{C}$. This last vat contains several pairs of rollers which take the tin plated sheets through the oil and out again. The sheets when finished are placed in oil at a low temperature so as to cool very gradually and are later freed from oil by scrubbing with bran and chalk.

Wire is usually tin plated by the same method as is used for zinc plating (q. v.), i. e. it is moved between two drums passing through an etching solution, then through an apparatus fitted with rags, &c. to wipe off the liquid, and finally through a vessel filled with molten tin.

Recently electrolytical methods have been proposed, though as yet no marked success has been obtained. According to ROSELEUR a bath is used containing 12 g tin salt and 100 g sodium phosphate to 10 litres H_2O ; the bath must be kept constant during the process by adding concentrated stannic chloride and sodium phosphate solution. The voltage should be 2–3 volts, the temperature not below 20°C ; the anodes are large sheets of tin.

See also the article on "TIN" for methods of removing tin.

Titanium. Ti. A.W. = 48.1. A rare element forming three oxides: titanium monoxide Ti_2O_3 , titanium oxide (titanic acid anhydride) TiO_2 and titanium sesquioxide Ti_2O_3 . The compounds of titanium are, on the whole, of little importance. According to Germ. Pat. 123860 good mordants are said to be obtained by treating titanium compounds with bisulphite, extracting with dilute H_2SO_4 and evaporating.

Germ. Pat. 152257 treats of the production and separation of titanium compounds, Germ. Pat. 150557 of the electrolytical preparation of titanium. — Germ. Pat. 136009 and 149577 deals with the preparation of solutions of titanic acid in lactic acid and combining titanic acid with lactic acid, respectively. — Amer. Pat. 742797 and French Pat. 338934 protect a process for the electrolytic reduction of organic substances by means of titanium compounds.

Titanium alloys, see "ALUMINIUM ALLOYS" No. 8 and "IRON ALLOYS" No. 10.

Tobacco. The leaves of various species of *Nicotiana* prepared for smoking, chewing and the manufacture of snuff. The important constituents are NICOTINE and TOBACCO OIL. The leaves are dried, laid in heaps and packed. The subsequent treatment varies according to the purpose for which the tobacco is intended. Generally a further fermentation takes place after the addition of certain liquors containing spices, sugar, salt, nitre, &c. which develop the aroma. The leaves are then rolled, or cut and dried, or roasted.

Usually, tobacco for smoking purposes is only once fermented and treated with water, a decoction of ashes or with weak acids. The percentage of nicotine varies inversely as the quality of the tobacco.

Recently ozone has been used to improve the quality of the tobacco leaf and to make it burn more readily.

Attempts have been made to render tobacco harmless for smoking purposes. With this object the nicotine has been extracted, but since by these means other constituents are removed, the aroma is destroyed and the tobacco tastes like straw. Another plan is to pass the tobacco smoke through fibrous materials which absorb the poisonous constituents. To increase the effect of this process, the "filter" is sometimes moistened with acids. The method proposed by THOMS (Germ. Pat. 145727) is comparatively successful. According to this the mouth piece of the cigar contains a wad impregnated with $FeCl_3$, $FeSO_4$ or better with ferrous ammonium sulphate. In this way the oils formed by combustion and the H_2S are completely removed, while the bulk of the nicotine and its decomposition products and half of the HCN are absorbed.

According to Germ. Pat. 178962 the nicotine is set free by treatment with alkalis, after which the tobacco is dried *in vacuo* without any rise of temperature.

To increase the aromatic flavour of tobacco, cigars, cigarettes, &c. methyl-eugenol, methylisoeugenol and their homologues are added, either to the raw or to the manufactured product.

Tobacco vacuum apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Tobacco extract. A dark-brown, viscid liquid with a faint but not unpleasant smell, prepared from tobacco leaves or stems (ribs). In 1–2% solution it is used successfully for the destruction of parasites on domestic animals (itch, mange, &c.). It is also used for killing plant pests.

^o-Tolidine. $C_{14}H_{12} \cdot (NH_2)_2 = p\text{-amido-o-ditolyl}NH_2 \cdot (CH_3) \cdot C_6H_3(CH_3) \cdot NH_2$. Obtained by treating hydrazotoluene with HCl. Hydrazotoluene is obtained by

the reduction of o-nitrotoluene with sodium amalgam. It may also be obtained by treating azotoluene with Sn and HCl.

It forms bright scales M. P. 128°. In addition to the free base, the chloride and sulphate, as moist pastes, are sold. It is used in the manufacture of various azodyes.

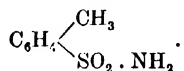
Tolu balsam. Obtained from *Tolujera Balsamum* which grows in South-America. The stem is cut and the sap exudes as a brownish-yellow liquid. It comes into the market as a brownish red, crumbly, crystalline substance. It has a sweet taste and resembles in odour Peru balsam, to which it is closely allied. It is used in medicine and perfumery.

Toluene (methyl benzene). $C_6H_5 \cdot CH_3$. A homologue of benzene. It occurs principally in the 50 % benzene and in the higher boiling oils. It cannot be separated by fractionation. On a commercial scale some of the hydrocarbons of the fatty series are removed by shaking with a mixture of HNO_3 and H_2SO_4 . The olefines polymerize, the hydrocarbons remain unchanged and may be removed by distillation in steam. On a small scale the impurities are removed by boiling the oils with sodium when they separate as resins.

Pure toluene is very similar to benzene. S. G. 0.87; B. P. 110°. It should distil completely within one degree. At -28° it is still liquid. Toluene is used in the preparation of dyestuffs, synthetic drugs and perfumes.

TEST. The examination is similar to that of benzene (q. v.). It should distil within one degree and when shaken with an equal vol. of concentrated H_2SO_4 for some time it should give no colouration. When 90 ccm toluene are shaken with 10 ccm HNO_3 (S. G. 1.44) in a tall glass-stoppered cylinder, the acid should be coloured red, remain clear and not become viscid or greenish in colour.

o-Toluenesulphamide.



Prepared by various methods (see SACCHARINE under "SWEETENING MATERIALS"). It is used in the sweet-stuff and dyeing industries and in the preparation of drugs.

Toluidines (amidotoluenes). $C_6H_4(CH_3)NH_2$. The preparation is similar to that of aniline (q. v.). See also under "ANILINE". Germ. Pat. 139457 and 144809 and the electrolytical preparation.

When toluene is nitrated the three isomers are formed simultaneously, and on subsequent reduction the three toluidines are formed. The meta-compound is the one present in least quantity. The separation from each other and from aniline is of the greatest importance.

The mixture of toluidines is strongly cooled when the para-compound separates and is removed by filtration under pressure. The crude toluidines may also be treated with HCl and oxalic acid and heated to boiling: the sparingly soluble p-toluidine oxalate separates while o-toluidine hydrochloride remains in solution. The methods of separating aniline and the toluidines depend partly upon the different strengths of the bases and partly upon the different solubilities of the acetyl compounds of aniline and p-toluidine.

The patented method of WUELFING is interesting. This depends upon the fact that only those amines in which the para position is unoccupied can be readily converted into amidoazo-compounds. After treatment with HCl and $NaNO_2$ the unaltered p-toluidine is separated by distillation in steam. Another

method, also due to WUELFING, depends upon the fact that the sulphonation of toluidines is only successful when the para position is unoccupied. The para-toluidine in this process therefore remains unchanged.

o-TOLUIDINE is a colourless oil turning brown in the air. S. G. 1.00; B. P. 198°. Very similar to aniline but distinguished from it by the smaller solubility of the nitrate and the greater solubility of the hydrochlorides. o-toluidine oxalate is soluble in 250 parts of ether.

m-TOLUIDINE is a colourless oil. S. G. (at 25°) 0.998. B. P. 197°. Present in aniline oil in small quantities only.

p-TOLUIDINE forms colourless crystalline leaves, sparingly soluble in cold water, readily in benzene, alcohol and ether. M. P. 45°; B. P. 198°. It is almost insoluble in ether.

The toluidines are used in the manufacture of dyestuffs.

Toluyl- and Toly compounds. See:—“TOLUENE”, “NITROTOLUENE”, “DINITROTOLUENE”, “TRINITROTOLUENE”, “TOLUIDINE”, “TOLIDINE”, “CRESOLS” and “TOLUYLENEDIAMINE”. — Azotoluene and amidoazotoluene are mentioned in the article on “AZO-COMPOUNDS”.

Toluylenediamine. $C_6H_3(CH_3)(NH_2)_2$. Chiefly o-p-toluylenediamine ($CH_3 : NH_2 : NH_2 = 1 : 2 : 4$) is used; it is obtained by reducing dinitrotoluene (q. v.) with $Fe + HCl$. It is generally used as an aqueous solution for various purposes, e. g. the manufacture of coal-tar dyestuffs.

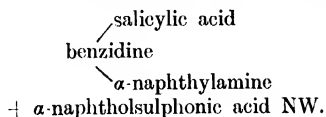
Tombac, see “COPPER ALLOYS”.

Trasulphane. Another name for *Ammonium sulphoichthiolicum*.

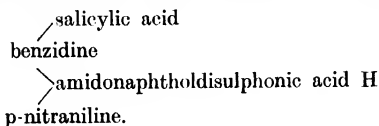
Triazo-dyestuffs. Group of dyestuffs containing the azo-group $-N=N-$ three times. See the articles on “AZO-DYESTUFFS”, “DIAZO-DYESTUFFS” and “TETRAZO-DYESTUFFS”.

Triazo-dyes may be obtained from a diamidoazo-compound, or a diamine, also from one diamine and one monamine, or from a triamine.

To the first group belongs DIANTHINE (Sodium salt of diamidoazoxytoluene-disazo-bi-1-naphthol-4-sulphonic acid) obtained by the condensation of 1 mol. diamidoazoxytoluene with 2 mol. a-naphtholsulphonic acid NW. An example of the second group is benzo-grey of the following constitution:



Diamine green is obtained from one diamine and one monamine, as follows:



Alizarine yellow FS is obtained from a triamine by the action of salicylic acid on fuchsine.

Tribromphenol see “BROMOL”.

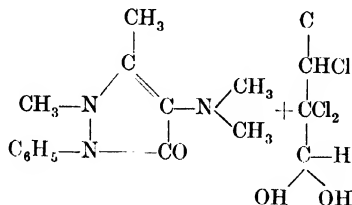
Trichloracetic acid, see “CHLORACETIC ACIDS”.

Trichlormethane, see "CHLOROFORM".

Triresol. A purified mixture of the three cresols (see "CRESOLS"), containing about 35 % o-cresol, 40 % m-cresol and 25 % p-cresol.

Triformol. For preparation and synthesis see "FORMALDEHYDE". It is used as a disinfectant.

Trigemine = dimethylamidoantipyrinebutylchloralhydrate. $C_{17}H_{24}N_3O_3Cl_3$. The constitution is



Butyl chloralhydrate is allowed to act on dimethylamidoantipyrine and the product of reaction purified by recrystallization from alcohol or benzene.

A fine, white, slightly hygroscopic, crystalline powder. M. P. 85° , soluble in H_2O , easily soluble in alcohol and benzene, sparingly in ether and ligroin. In consequence of its analgetic effect it is prescribed for headaches, neuralgia, &c.; it is also a mild antipyretic. Dose 0.5—1.2 g.

A clear liquid S. G. 1.042—1.049, dissolving completely to the extent of 2.2 to 2.55 % in water. The solutions are used as powerful antiseptics.

Trimethylbenzene, see "CUMENE".

Trinitrine, see "NITROGLYCERINE".

Trinitrobenzene. $\text{C}_6\text{H}_3(\text{NO}_2)_3$. Trinitrotoluene is oxidized (according to Germ. Pat. 127325) in strong H_2SO_4 with chromic acid, the product being trinitrobenzoic acid. The latter loses CO_2 on heating yielding trinitrobenzene.

Trinitroglycerine, see "NITROGLYCERINE".

Trinitrophenol, see "PICRIC ACID".

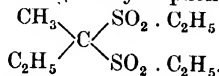
Trinitrotoluene. $\text{C}_6\text{H}_2(\text{CH}_3)(\text{NO}_2)_3$. Trinitrotoluenes are obtained from toluene in the same way as trinitrophenol is from phenol (see "PICRIC ACID", "NITROTOLUENE" and "DINITROTOLUENE".)

Trinitrotoluene is used in the manufacture of explosives; the M. P. lies between 71° and 80° .

Trinitrotoluene:

Sprenstoff A.-G. Carbonit, Hamburg.

Trional = methylsulphonal (Diethylsulphonemethylethylmethane).



It is obtained like sulphonal (q. v.) by the condensation of methylethylketone with mercaptan and the subsequent oxidation of the resulting mercaptol with KMnO_4 .

Colourless crystalline scales M. P. 76°C , readily soluble in alcohol and ether, sparingly soluble in H_2O . It is a good soporific. First dose 1.5 g, afterwards 1.0 g.

Trioxymethylene, see "FORMALDEHYDE".

Triphenine = propionyl-p-phenetidine. $\text{C}_6\text{H}_4(\text{OC}_2\text{H}_5)\text{NH}(\text{CO} \cdot \text{CH}_2 \cdot \text{CH}_3)$. The preparation is similar to that of phenacetine (q. v.). It is obtained by heating p-phenetidine with propionic acid.

Colourless crystals M. P. 120° , very sparingly soluble in H_2O . It is used as an antipyretic and antineuralgic.

Triphenylmethane dyestuffs. A class of dyestuffs derived from triphenylmethane $\text{HC}(\text{C}_6\text{H}_5)_3$. Amongst them are amidotriphenylmethane dyestuffs (q. v.), oxytriphenylmethane dyestuffs (q. v.) and phthaleins. For the latter see "PYRONINE DYE STUFFS".

Tropacocaine = benzoyl- ψ -tropine. $\text{C}_{15}\text{H}_{19}\text{NO}_3$. A base, found in minute quantities with the cocaine alkaloids; M. P. 49° . The preparation is protected by Germ. Pat. 88270, 89597 and 89999.

It is an excellent local anaesthetic and is coming more into use.

Tropone. A food preparation consisting of pure coagulated albumin from animal and vegetable residues, especially from meat flour, i. e. from the residues obtained in the preparation of extracts of meat. The material is treated with very dilute alkali and the proteid substances separated from the solutions by acids. The impurities are removed by treatment with H_2O_2 and hypochlorous acid. As a rule tropone is a mixture of $\frac{1}{3}$ animal and $\frac{2}{3}$ vegetable proteid substance.

Tropone is a dry powder. 1 kg tropone possesses (according to its content of albumin) the nutrient value of 200 eggs. It is given as soups and beverages and also baked with dough (tropone bread). Besides pure tropone, products containing iron (iron tropone), with nutrient salts, with flour (children's food), &c. are sold.

Tubes.

Copper tubes:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Tubes (copper, lead, porcelain, glass, transparent fused silica glass):

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Earthenware tubes:

Fr. Chr. Fikentscher Ltd., Zwickau Sa., Germany (see front part advt.).

Westdeutsche Steinzeug, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Tumenol. Including 1. TUMENOL, 2. TUMENOLSULPHONE, 3. TUMENOL-POWDER (tumenol sulphonic acid) and 4. TUMENOL AMMONIA.

Tumenol is obtained by sulphonating the mineral oils obtained from bituminous shist. It is a mixture of tumenolsulphone and tumenolsulphonic acid. These two ingredients are separated by treating the *Tumenol venale* with soda lye and extracting the reaction product with ether to obtain the tumenolsulphone. The sodium salt of the tumenolsulphonic acid, being insoluble in ether, remains behind after the extraction. The tumenolsulphonic acid is separated in the form of a dark powder from the salt by treatment with HCl.

Tumenol is a dark oil of the consistency of syrup, nearly insoluble in H_2O , readily soluble in oils. The properties of tumenolsulphone are similar. Tumenol sulphonic acid on the other hand is a dark-coloured powder, readily soluble in hot H_2O , sparingly in cold. Tumenol ammonia is an oily liquid.

Tumenol is used medicinally in the external treatment of skin diseases, wounds, burns, &c. It has a drying effect. Tumenol ammonia is generally used.

Tungsten. W. At. wt. = 184.1. Tungsten is found in nature in the form of tungstates, as scheelite $CaWO_4$, as stolzite $PbWO_4$, and as wolframite $(Fe, Mn)WO_4$. The metal is obtained by reduction of the oxide or chloride in a current of hydrogen or with carbon in the electric furnace. According to Germ. Pat. 141811. Pure tungsten is obtained from tungsten ores, slags, etc. by smelting at first with $NaHSO_4$ alone at a temperature of 300° and then with bisulphate and lime or calcium salts ($CaCO_3$, $CaCl_2$, etc.) with addition of alkali chlorides at 800° . It is important that the bisulphate should be in excess. If the process is properly conducted all the tungsten is obtained in the form of tungstic acid which can be reduced to metallic W. Germ. Pat. 149556 is similar to the above patent.

Germ. Pat. 147326 deals with the preparation of the metals of the iron group in electric furnaces. See "CHROMIUM".

Tungsten forms a lustrous, hard, steel-grey powder which is only fusible with difficulty. S. G. 19.13. According to von Wartenberg the M. P. lies between 2800° and 2850° . The alloys and compounds of tungsten have recently become commercially important. Tungsten itself is now used in the manufacture of tungsten lamps (q. v.).

Tungsten :

George T. Holloway, 57 Chancery Lane, London E.C.
Wesenfeld, Dicke & Cie., Barmen-R., Germany.

Tungsten alloys.

1. **FERRO TUNGSTEN.** Wolframite is washed and treated with HCl in order to remove S and As. The purified ore is treated with carbon and iron-ores in closed crucibles or is fused directly with cast-iron in cupola furnaces. It is used in the preparation of tungsten steel. Compare "IRON ALLOYS".

Ferro tungsten :

Wesenfeld, Dicke & Cie., Barmen-R., Germany.

2. **TUNGSTEN STEEL.** To molten steel (in the crucible) ferro-tungsten or (more recently) pure tungsten is added to the extent of 5–8 %. The addition of tungsten raises the hardness without affecting the temper of the steel. The welding properties, etc. are not diminished by the addition of tungsten as is the case when the carbon content is increased. The greater the percentage of W the smaller should be the amount of C present (not more than 1.5 % C should be present). See "IRON ALLOYS".

Tungsten alloys :

George T. Holloway, 57 Chancery Lane, London E.C.
Wesenfeld, Dicke & Cie., Barmen-R., Germany.

3. **TUNGSTEN-BRONZE.** This term is used to denote an alloy containing 95 % Cu, 3 % Sn and 2 % W, or sodium ditungstate + tungsten dioxide, $Na_2W_2O_7(Na_2W_2O_5 + WO_3)$. This substance, obtained by heating sodium tungstate and tungstic acid in a current of coal-gas or of hydrogen, forms fine golden cubical crystals. It is of commercial importance.

Tungsten compounds.

1. **TUNGSTIC ACID** (Tungsten trioxide) WO_3 . Obtained by precipitating a solution of sodium tungstate (see "SODIUM COMPOUNDS") with HCl . It is better to treat the sodium tungstate with CaCl_2 and then to decompose the calcium salt with HCl . WO_3 may also be obtained directly from wolframite by treating the mineral with HCl and HNO_3 to remove the Fe and Mn , and then dissolving the residue in NH_3 . The ammonium tungstate thus obtained, is heated when WO_3 is formed.

It is a lemon-yellow powder, insoluble in water and acid, used for the preparation of tungsten-bronze (q. v.) and tungsten blue. The latter compound is apparently an oxide of the formula W_2O_5 which has an intense blue colour and is insoluble in water. It is prepared by reducing WO_3 with $\text{Zn} + \text{HCl}$ or by heating gently in a current of hydrogen.

Tungsten compounds:

George T. Holloway, 57 Chancery Lane, London E.C.
Wesenfeld, Dicke & Cie., Barmen-R., Germany.

Tungstate of soda:

Wesenfeld, Dicke & Cie., Barmen-R., Germany.

Tungstic acid:

Wesenfeld, Dicke & Cie., Barmen-R., Germany.

Tungsten lamps. Incandescent electric lamps with a filament of metallic tungsten. They are made according to the methods protected by Germ. Pat. 154262, French. Pat. 373923 and Engl. Pat. 28154 (1904). The Kùzel lamps are made according to the last named patent. The Osram lamp contains a filament consisting mainly of tungsten to which is added a small percentage of an osmium compound.

These lamps, like other metallic filament lamps, consume less current and are in every way more economical than the carbon filament lamps, so that the disappearance of the latter is only a question of time.

Turkey red dyeing. A special method of dyeing cotton, wool and silk. It was formerly exclusively carried out with madder. Compare "ALIZARINE". As this dyestuff has, however, no affinity for either animal or vegetable fibres, the material to be dyed has in every case to be treated with a mordant. The compound used for this purpose determines the colour obtained. Fibres treated with an aluminium mordant are coloured red, with iron oxide violet, those with tin compounds orange, and with chromium oxide bordeaux. They are all fast to light, washing and milling.

There are two distinct methods of Turkey red dyeing; the older white vat process and the newer so-called Turkey red oil process. In the first case the cotton is treated with an emulsion of acid olive oil and sheep or cow dung and an aqueous solution of Na_2CO_3 for 24 hours. After this it is dried in the air at a moderate temperature to fix the insoluble oxy-fatty acids, formed by the oxidation, on the fibre. This operation is repeated twice and the material is then washed four times in a weak Na_2CO_3 bath, the so-called white bath, for the purpose of removing the excess of oil. The material is then sprinkled with water, washed, dried, and while still warm treated with sumach extract after which it is mordanted with a solution of basic alum. Then follows the real dyeing process with a solution of alizarine. After the material is dyed it is boiled with soap and tin salt to brighten the colour. The new Turkey red process is much less troublesome and takes far less time. A Turkey red oil neutralized with ammonia is used instead of the acid olive or Tournant oil. Compare "OIL MORDANTS". In the new red process the cotton is boiled with Na_2CO_3 , washed, saturated with warm neutralized Turkey red oil solution,

dried, steamed, treated with aluminium mordant, dyed, again treated with Turkey red oil, again steamed and finally brightened twice with soap (under pressure).

Until quite recently it was impossible to make use of the Turkey red lake in the ordinary dyeing process, as the alizarine necessary could not be used in a state of solution without injury to the valuable qualities of the lake. The new process patented by KORNFIELD renders it possible to work with the clear solutions necessary without the Turkey red lake colour being in any way affected. KORNFIELD used calcium saccharate for the purpose; this compound is sufficiently alkaline to keep the alizarine in solution, while also containing the amount of lime necessary for the production of the Turkey red. The lime is precipitated in the form of a calcium salt of alizarine only after the third substance having affinity for the alizarine is added, in this case the fibres mordanted with the aluminium salts of fatty acids.

Germ. Pat. 138391 dealing with the production of Turkey red or Turkey rose protects a modification or simplification of the new red process. It is particularly concerned with quickening the process by mordanting and a better fixing of the alumina and alizarine. The cotton is first, as in other cases, oiled and dried, but then — and here it differs from the usual methods formerly in vogue — the cotton is put into a weaker solution of a suitable aluminium salt and gradually warmed. This method is said to fix the alumina so perfectly on the fibre, that the hanging, drying or fixing with waterglass, soda or other substances is quite unnecessary. All that is necessary is to rinse a little after mordanting, when the material can at once be dyed. The aluminium salts recommended for this purpose by the inventor of the process are normal acetates, lactates, formates, chromates or phthalates or normal or acid sulphates. The same salts with excess of free acetic, formic or lactic acids can also be used.

Iso soap a new solid sulpho-derivature of castor oil:

Louis Blumer, Zwickau Sa., Germany.

Turpentine. A balsam exuding from the stems of various conifers. It is a sticky mass of the consistency of honey. The common turpentine is cloudy, becoming clear only on warming, while the finer sort is always clear.

Common turpentine is usually obtained by making cuts in the stems of the pine (more rarely the Scotch fir). It is a sticky, semi-liquid mass with an unpleasant smell. The French and American turpentines are similar. The Venetian or Venice turpentine is one of the finer kinds, it is a balsam, obtained from the larch, which is at first milky but soon becomes clear. Carpathian, Canada, Hungarian and Strasburg balsams also belong to the group of refined turpentine. (See "BALSAMS").

Turpentine is used in the preparation of oil of turpentine, resin and colophony, and also in the manufacture of varnishes, cements, sealing-wax, plasters, etc.

A resin, known as boiled turpentine, is obtained as a residue after distilling turpentine with steam. It forms a yellowish, solid, opaque mass.

Amer. Pat. 834759 protects a special distillation apparatus for turpentine. Amer. Pat. 856049 deals with a retort for recovering turpentine from finely-divided wood and sawdust. Amer. Pat. 851687, 852236, and 852078 deal with methods for extracting turpentine from wood, a mixture of wood-tar and pinewood oil being used for the purpose. (A bath of heated resin is used.)

Amer. Pat. 813088 and Norwegian Pat. 16277 (1906) deal with the refining of crude turpentine.

Test. According to Hirschsohn (Pharm. Zentralh. 1903, 825; Chem.-Ztg. 1903, Rep. 316) 10 % liquid ammonia and alcohol (80 % Tralles) are used

for distinguishing common turpentine, Venice turpentine and artificial turpentine according to the following scheme.

Kind of turpentine	Liquid Ammonia (S.G. 0.96) 1 turpentine + 5 NH ₃	Alcohol (80% Tr.) 1 turpentine + 3 alcohol
Venice turpentine	Is not dissolved. Turns milky on the water bath	Gives an almost clear solution
Common turpentine	Is readily changed into a milky solution which soon becomes gelatinous, but becomes clear on the water bath	Large amounts separate out. Clear solution on water bath
Artificial turpentine	Dissolves; solution at first clear, but soon becomes cloudy	Milky solution with separation of solid when heated on the water bath

Turpentine, Oil of.

Obtained from turpentine (q. v.) by distillation, either by direct or indirect steam. The oil is rectified by repeating the distillation with steam after adding 5 % slaked lime. For pharmaceutical purposes rectification must be repeated periodically since turpentine oil has a tendency to decompose in the air. Recently the production of turpentine oil by dry distillation has become more general.

The most important kinds of turpentine are French, English, and Russian. then German turpentine oil and dwarf pine oil.

So called pine wood oil is practically the same as turpentine oil; is it obtained from the resinous root wood of pines by dry distillation and subsequent rectification.

The Engl. Pat. 10004 (1903) deals with a method for removing the disagreeable smell from Russian turpentine. It is treated with the solution of an oxidizing agent like permanganate, chromic acid or persulphate (according to Germ. Pat. 170543 and 180207, the oil is treated first with alkali, then with an alcoholic solution of alkali and finally with dilute acid).

Crude turpentine oil is mobile, colourless or yellow, becomes resinous and viscous in air; when rectified it is colourless. S. G. 855—876; B. P. 156 to 161°. The terpene, pinene, is an ingredient. Turpentine oil absorbs O, converting it partly into ozone. When inhaled or taken internally in large doses it is injurious. It is used to make varnishes and oil paints, to dissolve caoutchouc. The oil containing ozone is used to bleach ivory and also as a medicament.

Distilling and rectifying apparatus for Turpentine Oil :

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Turpentine Oil :

Stora Kopparbergs Bergslags Akt'ebolag, Falun, Sweden.

Tussol = the antipyrine salt of mandelic acid, obtained by heating antipyrine with the required amount of mandelic acid on the water bath until the mixture melts; the cold mass is recrystallized from alcohol.

Colourless crystals of bitter taste, soluble in H₂O and in alcohol, M. P. 52—53° C.

Tussol possesses narcotic and antipyretic properties; it is prescribed as a specific for whooping cough and also for bronchial and laryngeal catarrh.

As milk decomposes tussol into its components, it may never be taken with milk, or immediately before or after milk.

U

Ultramarine (*Lapis lazuli*). A blue colouring matter formerly obtained from *Lapis lazuli* by powdering and washing. It is now prepared artificially by fusing together kaolin clay and sulphur with soda or with a mixture of Na_2SO_4 and charcoal. The methods employed are three in number:—

1. The soda method. 2. The sulphate method. 3. A combination of the above. 1. The kaolin is levigated and heated to a moderately high temperature. (It should be as free as possible from iron.) It is then mixed with pure Na_2CO_3 , sulphur free from arsenic and wood charcoal. Usually a portion of the Na_2CO_3 is replaced by Na_2SO_4 and colophony or brown-coal pitch added as a reducing agent.

The following recipe may be given as an example:— 100 parts kaolin, 46 parts Na_2CO_3 , 41 parts Na_2SO_4 , 13 parts S, and 17 parts charcoal. A better mixture is the following:—100 parts China clay, 90 parts Na_2CO_3 , 100 parts S, 4 parts charcoal and 6 parts colophony or pitch.

The fusion is carried out in fire clay crucibles at a low red heat; it is important that air should be excluded and that the reducing gases should not come in contact with the fused mass.

Sometimes the clay and the Na_2CO_3 are first melted together, giving a colour base which is then treated with the other materials in a second operation.

2. Sulphate ultramarine is prepared by first making an intimate mixture of 100 parts of kaolin, 80 parts of calcined Na_2SO_4 , 17 parts of charcoal and 10 parts of S; (the more Na_2SO_4 the less S, and the more S the less Na_2SO_4). On roasting a green product is first obtained, which is repeatedly extracted with H_2O , finely ground, pressed, dried, sifted, and finally burnt until blue. In order to obtain the blue the substance is roasted with sulphur in presence of air.

3. The combined process is based on the principle of mixing a charge of the materials used for making soda-ultramarine with a sulphate-ultramarine charge.

The crude ultramarine obtained by one or the other of these processes is boiled several times with H_2O when the Na_2SO_4 and Na_2SO_3 are removed. The substance is then ground, again extracted and the water removed either by centrifugal machines or in filter presses. Finally it is treated with 4 times the quantity of MgCO_3 for the finer products and 10 times the quantity of chalk, plaster of Paris, or kaolin for the inferior qualities, after which the mixture is ground. In some cases glycerine is added to give the preparation a darker shade. Preparations rich in SiO_2 can be worked up into ultramarine violet and ultramarine red. To make the violet shade, ultramarine blue is treated at a high temperature either with chlorine and steam, or with HCl and air, or again with sal ammoniac and nitrates. Ultramarine blue is converted into red by the action of HCl or HNO_3 vapours at (about) 130° .

Germ. Pat. 149203 claims to avoid the difficulties attending the use of so much sulphur and the large consumption of fuel in the manufacture of ultramarine, by surrounding the muffle in which the product is heated with double walls. The intervening space is connected with a ventilator, so that the sulphurous gases which are given off cannot escape but are conducted into a condensation apparatus. The muffle is also arranged in three parts and is worked like a blast furnace, there being at the top first a warming chamber into which the material to be calcined is brought, below this is the reaction chamber proper and finally the cooling chamber. Germ. Pat. 156335 employs a mixture of charcoal China, clay, sulphur, crude Na_2CO_3 , rice husks and other materials suitable for the preparation of ultramarine. The principal object of the process is to add the carbon and siliceous matter in the same

raw material; such a raw material is obtained by charring rice husks at a temperature of 300—400°.

The constitution of ultramarine is still unsettled. It is an azure-blue, hygroscopic powder without taste or smell, which does not dissolve in ordinary solvents but which in acids or salts with acid reactions, decomposes and loses its colour with evolution of H_2S .

Ultramarine is used for painting, for lime wash, for printing wall paper and textiles and for "blueing" discoloured substances such as sugar, paper, starch, linen, &c. The sensitiveness of ultramarine to the action of acids explains why the production of ultramarine is gradually diminishing.

Ultramarine yellow see "CHROME COLOURS".

Umber see "MINERAL COLOURS, NATURAL".

Unal see "PHOTOGRAPHIC CHEMICALS".

Uralite. An insulating incombustible product which at first resembles asbestos board, but after heating in furnaces, is hardened so that it is as hard as metal. A mixture of asbestos and Spanish white with gelatinous siliceous earth is rolled into plates 2 mm in thickness. These plates are heated in gas-furnaces, soaked in a solution of soda water-glass, dried, dipped into a solution of sodium bicarbonate, dried again and finally treated in a bath of KCl. The process is protected by various patents, among others by Germ. Pat. 143880.

Uralite plates are easily worked with carpenters' tools, resist bending to a considerable extent and are bad conductors of heat and electricity.

Urania blue. A coal-tar dyestuff of unknown constitution, obtained by the oxidation of β -dinaphthyl-m-phenylenediaminedisulphonic acid and p-amido-dimethylanilinethiosulphonic acid. It dyes wool and silk blue in acid baths.

Uranium and uranium compounds.

1. **URANIUM.** U. A. W. 239.4. A rare element, occurring chiefly in pitchblende, uranyl oxide $\text{U}_3\text{O}_8 = 2 \text{UO}_3 \cdot \text{UO}_2$. Uranium itself has recently been obtained by the reduction of uranium oxide, UO_3 with C in electric furnaces. It is an iron-like metal, as hard as steel, oxidizing at the surface in air; S. G. 18.7. The metal itself is of no industrial value. The compounds of uranium are not less poisonous than those of arsenic.

2. **URANIUM OXIDES.** The only important one is uranium trioxide UO_3 which remains as a yellow-brown powder when uranyl nitrate is heated to 200°. It dissolves readily in acids forming uranium oxide salts, the di-valent radical UO_2 taking the place of the metal.

By precipitating solutions of uranyl-salts with KOH, NaOH, NH_3 , $\text{Ba}(\text{OH})_2$, &c., uranium hydroxides are not obtained, but the salts of uranic acid (uranates), known commercially as uranium oxides and used to make uranium glass, i. e. glass with a yellow-green fluorescence. Sodium uranate (sodium di-uranate) $\text{Na}_2\text{U}_2\text{O}_7$ is made on a large scale and is sold as uranium yellow or sodium uranate.

3. **URANYL ACETATE.** $\text{UO}_2(\text{C}_2\text{H}_3\text{O}_2)_2$. Uranyl nitrate is heated until a little basic salt is formed. The orange-coloured residue is heated with a little concentrated acetic acid. On cooling, fine crystals of the acetate are obtained containing 3 mol. H_2O when formed below 10° C and 2 mol. H_2O when above 10°. Uranyl acetate is readily soluble in H_2O and alcohol; it readily forms double salts. It is used in analytical chemistry for the determination of phosphoric acid.

4. **URANYL NITRATE.** $\text{UO}_2(\text{NO}_3)_2$. Obtained pure by dissolving UO_3 in HNO_3 ; commercially from uranium pitch blende by various methods; the

following is a reliable process: pitchblende is stirred with dilute HNO_3 , Pb, Cu, and As are precipitated from the filtered solution by H_2S , the filtrate is evaporated to dryness and the cold residue extracted with H_2O (the oxides of Fe, Co and Mn remaining behind). When the solution is evaporated crystals of $\text{UO}_2(\text{NO}_3)_2$ are formed; these are purified by recrystallization. The crystals are large, yellow with a slight greenish cast, they dissolve in alcohol and ether, readily in H_2O . The salt is used for making other uranium preparations, and in photography.

5. URANYL PHOSPHATES. Of the various phosphates the acid salt $(\text{UO}_2)\text{HPO}_4$ is most important. It is prepared by treating uranyl acetate with phosphoric acid, or by treating the acetate or nitrate with Na_2HPO_4 , &c.

Uranium and compounds:

Johnson, Matthey & Co. Ltd., Hatton Garden, London E.C. (see advt.).

Urea (Carbamide). $\text{CO}(\text{NH}_2)_2$. Synthetically obtained by the intramolecular rearrangement of ammonium isocyanate ($\text{CON} \cdot \text{NH}_4 \rightarrow \text{CO}(\text{NH}_2)_2$). Equivalent amounts of potassium cyanate and ammonium sulphate in aqueous solution are evaporated; when the concentrated solution cools K_2SO_4 crystallizes out; it is filtered off, the solution evaporated further and the urea extracted from the residue with hot alcohol. Recently urea has been obtained from calcium-cyanide (see "CALCIUM COMPOUNDS"), since cyanamide is converted into urea in the presence of water; it is not, however, likely that this process (protected by the Amer. Pat. 796713) will be practicable.

Urea occurs in the urine of mammals. The urine is usually evaporated and HNO_3 added and the urea thus separated as nitrate.

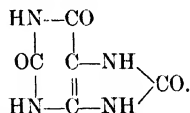
It forms long rhombic crystalline prisms or needles, with a cooling taste, like that of KNO_3 . M. P. $132-133^\circ$. It dissolves in 1 part cold H_2O and 5 parts alcohol; almost insoluble in ether.

Urea:

C. Erdmann, Leipzig-Lindenau.

Uresine. Lithium urotropine citrate. Used as a diuretic.

Uric acid. $\text{C}_5\text{H}_4\text{N}_4\text{O}_3$. The constitution is as follows:—



Uric acid is usually obtained from Peru guano. This is dried, powdered, and heated with concentrated H_2SO_4 to 100° , and kept at this temperature till all the HCl and HF are expelled. It is then allowed to cool when it is much diluted with H_2O and allowed to stand for several days. After this it is filtered and the washed precipitate is put into boiling potash lye (8 % KOH). The solution thus obtained is filtered, warmed with animal charcoal, filtered while still warm and allowed to run into HCl, when the uric acid separates. The product is purified by repeating the process of precipitation and solution and is finally recrystallized. The acid is also prepared from the excrement of snakes.

Uric acid is a crystalline, granular white powder without taste or smell. It is insoluble in ether or alcohol and almost insoluble in cold H_2O . It dissolves with difficulty in hot H_2O . It is a dibasic acid.

Urocital. Sodium theobromine citrate $\text{C}_7\text{H}_7\text{N}_4\text{O}_2\text{Na} \cdot \text{C}_3\text{H}_4(\text{OH})(\text{COONa})_2$. Used as a diuretic.

Urogosan. A compound of gonosan and hexamethylenetetramine prepared in gelatine capsules. Recommended as a disinfectant for the bladder.

Urol = the urea salt of quinic acid. It is prepared according to the Germ. Pat. 124426.

It is highly recommended for gout on account of its great power of dissolving uric acid.

Urosine. 50 % aqueous solution of the lithium salt of quinic acid. Prescribed for gout.

Urotropine see "HEXAMETHYLENTETRAMINE".

New urotropine is hexamethylenetetraminecanhydromethylene citrate.

Ursol. Dyestuffs of unknown constitution produced on the fibre by the oxidation of p-phenylenediamine or p-amidophenolhydrochloride with hydrogen peroxide or $K_2Cr_2O_7$. Ursol is chiefly used in the dyeing of hair (fur &c.). It gives brown to black colours.

Urystamine = lithiumhexamethylenetetraminebenzoate. Recommended for gout.

V

Vacuum apparatus.

Vacuum apparatus:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

C. Harzer & Co., Finsbury Pavement House London E.C.

Emil Passburg, 30 Great Street, Helens, London E.C.

Werner Pfeleiderer & Perkins Ltd., Peterborough.

Wogelin & Huebner A.-G., Halle a. d. S., Germany.

Vacuum plants:

Ernest Scott & Co., 2 Talbot Court, London E.C.

Earthenware vacuum apparatus:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Vacuum drying apparatus:

Friedrich Heckmann, Berlin SO. 16, Brückenstr. 6b (see advts.).

Vacuum drying cupboard of cast iron and forged iron:

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Valeric acid. $C_5H_{10}O_2$. A fatty acid occurring in two modifications, the normal acid (propylacetic acid) and the iso-acid (isopropylacetic acid). It occurs in the form of esters in many plants and also in blubber. The normal acid is found in crude wood vinegar. Ordinary valeric acid is obtained from the roots of *Valeriana officinalis* by distillation with water with the addition of H_3PO_4 . It is also prepared by the oxidation of alcohol (fusel oil) with $K_2Cr_2O_7 + H_2SO_4$.

Valeric acid forms a monohydrate and a trihydrate; it is a colourless, clear, oily liquid having a strong odour resembling that of valerian and decomposing cheese. S. G. (at 20°) 0.931; B. P. 176.3°. The salts usually have the peculiar odour of the free acid. Amyl valerate and ethyl valerate are of importance in the preparation of fruit essences.

Valerydine = isovaleryl-p-phenetidine. Prescribed in cases of neuralgia, headache, hysteria, &c. Now little used.

Validol = menthol valerate. It is prepared by warming 16 parts menthol with 12 parts valeryl chloride, adding dilute NaOH solution, extracting with ether and fractionating under reduced pressure.

Valves.

Valves (Acid-proof):

C. Harzer & Co., Finsbury Pavement House London E.C.

Valyl = diethylvaleramide. $\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO} \cdot \text{N}(\text{C}_2\text{H}_5)_2$. Obtained by the action of ethylamine on valeric anhydride. A clear liquid having a smell of pepper, prescribed for hysteria, neurasthenia, hypochondria, neuralgia, and palpitation of the heart.

Vanadium and vanadium compounds.

1. **VANADIUM.** V. A. W. 51.2. The metal may be prepared with difficulty by the reduction of vanadic acid with C in electric furnaces. (Engl. Pat. 12727, 1903). According to Germ. Pat. 153619 an anode consisting of an intimate mixture of vanadium trioxide and carbon and a cathode of iron are used in an electrolyte which consists of iron fluoride dissolved in fused calcium fluoride. VF_3 is first formed and this then decomposes into V and F. The vanadium forms alloys with the iron of the cathode. See "IRON ALLOYS".

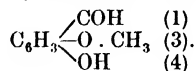
2. **VANADIUM PENTOXIDE** (Vanadic acid). V_2O_5 is the most important compound. In order to prepare it, vanadinite is dissolved in HCl and from the solution ammonium vanadate is precipitated by the addition of NH_4Cl . On heating this the oxide is obtained and this is further purified. After fusion it solidifies either in the amorphous form or as reddish-brown needles which dissolve in 1000 parts H_2O giving a yellow solution with an acid reaction.

V_2O_5 has recently been prepared from the slags obtained in the de-phosphorizing of iron.

The vanadates are usually meta-salts (corresponding to HVO_3) but ortho- and pyro-compounds are also known. Vanadic acid is used as a catalytic agent in the manufacture of H_2SO_4 and also for producing aniline black.

When heated in a current of hydrogen V_2O_5 is reduced to V_2O_3 .

Vanilline (protocatechuicaldehydemethylether).



This perfume, so widely distributed in nature, can be prepared in various ways, e. g. from the glucoside coniferine contained in the sap of *Conifera* by oxidation with CrO_3 . The preparation from eugenol (q. v.) (or still better isoeugenol, q. v.) is carried out by acetylating with acetic anhydride, oxidizing the acetyl-isoeugenol with CrO_3 to acetovanilline, and then splitting off the acetyl group. Further piperonal (q. v.) may be taken as the starting point, and this converted into protocatechuic aldehyde. It forms white crystalline needles with an intense smell of vanilla. M. P. 80—81°. B. P. 285°.

Vans.

Earthenware vans:

Fr. Chr. Fikentscher Ltd., Zwickau Sa., Germany (see front part advt.).

Vaporine = naphthalene-eucalypto-camphor. The preparation is mixed with boiling water and inhaled. Highly recommended by physicians for whooping-cough.

Varnishes. Liquids applied as a thin coating which on drying form hard shining layers, preserving the object from atmospheric influences. Varnishes are classed under three heads, 1. **OIL VARNISHES** made with linseed oil and other drying oils. 2. **LAC VARNISH** or lacquer made of resin dissolved in drying oils. 3. **VOLATILE VARNISHES**, such as turpentine varnish and spirit varnish, made of resin dissolved in alcohol, ether, turpentine oil, acetone, benzine, &c.

The method of making oil varnishes is given in the article on "LINSEED OIL VARNISHES" and that of making lacquer under "PRINTER'S VARNISH". In this article we have to consider those included under 3., the volatile varnishes.

These varnishes are as a rule not so durable as those made with oil. The fundamental material shellac, mastic, turpentine, colophony or dammar is dissolved in one of the above volatile substances. Dammar varnish is a solution of this resin in boiling turpentine oil; the addition of linseed oil renders the product less brittle whereas if copal is mixed with the dammar the varnish will be harder. Gold lacquer, or gold varnish is a turpentine oil varnish made of mastic, sandarac and colophony with some colouring stuff such as picric acid, and, as a rule, a small addition of linseed oil varnish and copal lacquer.

The alcoholic varnishes dry very quickly and leave a very shiny surface; they very easily crack if not mixed with a little mastic, elemi, &c.

For further particulars see under "LAC", "ASPHALT LAC" and "LINSEED OIL VARNISHES".

The following mixtures for varnishes have been found very satisfactory and can be safely recommended.

1. **HARD WHITE SPIRIT LACQUER.** 225 g of mastic, 225 g of sandarac and 225 g of Venetian turpentine in 2.2 litres of methylated spirit dissolved with vigorous shaking to prevent coagulation of the resin.

2. **LIGHT COLOURED SPIRIT VARNISH.** 450 g of sandarac and 34 g of Venetian turpentine in 2.2 litres of methylated spirit dissolved with vigorous shaking.

3. **TRANSPARENT VARNISH.** 455 g of sandarac, 225 g of mastic and 115 g of dammar dissolved in 2.2 litres of methylated spirit with vigorous shaking.

4. **MAHOGANY VARNISH.** 450 g of sandarac, 115 g of shellac, 225 g of colophony, 340 g of Venetian turpentine and 57 g of elemi resin in 4.5 litres of methylated spirit dissolved with continual shaking. If the varnish is too light 7 g of Bismarck brown should be added.

5. **PRINTER'S VARNISH.** 1.2 kg of Venetian turpentine and 3 kg of pale shellac dissolved in 9 kg of methylated spirit.

6. **TICKET VARNISH.** 1.5 kg Manilla copal, 400 g of Venetian turpentine and 400 g of gallipot.

7. **PICTURE VARNISH.** 800 g of Venetian turpentine and 800 g of sandarac dissolved in 2.8 kg of methylated spirit.

Vaseline. (*Adeps mineralis*, *Adeps petrolei*.) This substance is an indifferent fat- or ointment-like transparent yellow, or (if purified) white product with only a faint smell, prepared from petroleum, principally in America in the rectification of petroleum. Compare "PETROLEUM". Light kinds of Pennsylvanian native oil are heated at a low temperature by injecting hot air till the desired specific gravity 0.865—0.875 is reached, whereupon it is filtered over warmed animal charcoal to decolourize it. Another method of preparation which is also used for German and Galician mineral oil is to refine the residues from illuminating oil, generally diluted with benzine, by repeated treatment with H_2SO_4 .

The decolourizing of the vaseline is carried out by means of the so-called decolourizing powder. Compare "PETROLEUM". Artificial vaseline is obtained by melting 1 part of ceresine with 4 parts of liquid paraffin. Compare "CERESINE".

The melting point of vaseline varies according to the original product and method of preparation; it lies between 33° and 45° , while the S. G. varies in the same way between 0.855 and 0.880. It is a mixture of solid and liquid hydrocarbons, used for making ointments, cosmetics and pomades, further as a protection against rust on metals, as a lubricant for machines and wheels, and in the manufacture of smokeless powder.

A product is brought on the market under the name of vaseline oil which is a colourless odourless mineral oil employed as a dressing for the hair and as a lubricant for fine machinery.

Vaseline oil see "VASELINE".

Vasogene. Obtained from vaseline and ammonium oleate by a process of which the details are kept secret.

Vats and vat dyestuffs. The most important vat dye is indigo; see the article on "INDIGO DYES". As indigo blue is completely insoluble it is converted by means of reducing agents into indigo white which is soluble in alkaline liquids; such a solution is known as the indigo vat or blue vat. Vat dyeing consists in dipping the fibres into the vat. Indigo white settles on and in the fibres and is readily reoxidized in the air to indigo-blue which is then insoluble and cannot be removed from the fibre. On account of the indigo white in this case turning through green into blue the process is also called the "greening" of the fibre.

The indigo vats may be divided into cold vats and warm vats (fermenting tubs); the former are used for cotton and silk and the latter usually for wool.

The cold vats may again be divided into the vitriol, zinc and sulphite vats. The vitriol vat is made from indigo, ferrous sulphate, and lime; the lime precipitates ferrous hydroxide from the iron vitriol and this reduces indigo to indigo white. In the zinc vat (zinc dust vat) the iron vitriol is replaced by zinc dust. The hydrosulphite vat has become especially important; in this sodium hydrosulphite, zinc hydrosulphite, lead hydrosulphite, calcium hydrosulphite, &c., are employed for the reduction of the indigo. With regard to the preparation of hydrosulphites see article on "HYDROSULPHITES". Many patents have been taken out on the subject of the hydrosulphite vat dyeing and the most important is that concerning the manufacture of stable hydrosulphites by means of formaldehyde.

In the fermenting vats are to be distinguished woad vats, potash vats, soda vats, and urine vats. All fermenting vats depend on the principle that hydrogen is liberated by the fermentation of organic substances and this hydrogen reduces the indigo. The woad vat consists of a mixture of indigo, woad, bran, madder, and slaked lime; the woad is itself a plant containing indigo; it is, however, no longer used alone for dyeing but merely for causing the fermentation. The mixture is allowed to ferment by standing from one to one and a half days at a temperature of 50 – 60° . The potash vat consists of madder, bran, potash, and indigo; the soda vat (German vat) consists of bran, indigo, soda, and slaked lime. The urine vat is a solution of indigo and madder in putrid urine with the addition of common salt. All fermenting operations are carried out at a temperature of 30 – 40° C; the above mentioned sulphite vat is also used in wool dyeing at this temperature.

The hydrosulphite vat is at present the most important in indigo dyeing. Among the improvements may be mentioned that aiming at the preparation of acid indigo-white solutions. For instance Germ. Pat. 137884 describes a method for making the so-called boric acid vat, which is an alkaline solution of indigo white containing an excess of boric acid. According to Germ. Pat. 144788 a deep indigo dye on cloth may be obtained by treating the fibres

with free indigo white, and not in an alkaline vat (solution of indigo white in soda). In order to prevent the precipitation of indigo white on acidifying the hydrosulphite vat (which is advantageously carried out with sodium bisulphite), starch, gum, paste, dextrine, albumen, &c. are previously added to the vat. Germ. Pat. 152907 adds to the hydrosulphite vat (in the dyeing of wool with indigo) an ammonium salt (e. g. NH_4Cl) and a proteid (glue, albumen or caseine) by means of which an excess of fixed alkali is removed and the indigo-white kept in a favourable state for the dyeing.

According to Germ. Pat. 139567 indigo white and indigo vats may be prepared electrolytically by electrolyzing indigo with or without a diaphragm in the presence of a warm solution of sulphite. If a diaphragm be used and the anode chamber contain H_2SO_4 the indigo white is said to be obtained in a stable transportable form. Germ. Pat. 153577 for the preparation of leuco-indigo is mentioned in article on "INDIGO DYES".

According to Germ. Pat. 165429 indigo and its homologues may be converted directly into leuco-derivatives by means of iron if solutions of caustic alkalis of at least 10° Bé be used and heated to 70° . The use of iron is not only of advantage on account of its cheapness but also because it does not dissolve in the vat and produces strong indigo white filtrates which can be used as such. Besides indigo indophenol is also used as a vat dye; this is also converted by reducing agents into indophenol white. The blue indophenol is then re-precipitated on the fibre by means of strong oxidizing agents. Besides the pure indophenol vats the mixed indigo-indophenol vats (in which a mixture of 1 part indophenol and 3 parts of indigo is employed) have recently been used with great advantage.

The indanthrene dyes recently introduced into commerce are also made soluble in the form of vats and fixed in the vat dyeing.

According to Germ. Pat. 146707 sulphur dyes can be dyed in the vat by converting the dyes in an alkaline vat into the leuco-substances which have a strong affinity for the fibres and can be brought on to the fibres at a low temperature. The oxidation of the leuco-compounds begins at once as soon as the articles are taken out of the bath. The ordinary after-treatment with metallic salts or oxidizing agents can of course also be carried out here.

Earthenware-vat for burning off.:

Westdeutsche Steinzeug-, Chamotte- und Dinaswerke G. m. b. H., Euskirchen, Rheinland (Germany) (see front part advt. p.).

Vegetaline. The name given to a preparation of lactic acid used in tanning for removing lime, for plumping, &c. It is obtained according to Germ. Pat. 104281 and 113385 from the drainage water from preserve manufacture (especially SAUERKRAUT-works) by direct evaporation. The amount of lactic acid present varies between 8.6 and 9.6 %.

Venetian white see "LEAD COLOURS".

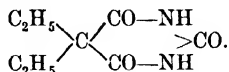
Veratrine. A mixture of several bases obtained from *Semen sabadillae*. The seed is crushed and extracted several times with dilute hydrochloric acid. The extract is concentrated and the veratrine precipitated with $\text{Ca}(\text{OH})_2$. It is extracted from the precipitate with alcohol, the latter evaporated again and the alkaloid taken up from the residue with acetic acid. From the filtrate it is precipitated with NH_3 or Na_2CO_3 , extracted with ether, the latter evaporated the residue again dissolved in acetic acid, the solution purified with animal charcoal and the purified veratrine finally precipitated in a hot solution with NH_3 . As the minutest quantities of veratrine seriously affect the mucous membranes the greatest care is necessary during the preparation.

White odourless powder, the dust of which produces violent sneezing; very readily soluble in alcohol, chloroform, and ether.

Veratrine is a strong base; medicinally it is probably now only used externally in the form of ointments, &c., internally hardly at all and very rarely in injections. It is a strong poison.

Verbena, oil of. Volatile oil obtained in India and Arabia from *Andropogon nardus* by distillation with H_2O . It is colourless, smells strongly of roses and is used in perfumery.

Veronal = diethylmalonylurea.



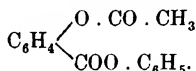
White crystalline powder with a slightly bitter taste, M. P. 191°C , readily soluble in ether, acetone, warm alcohol; it also dissolves in about 12 parts of boiling water.

It is an excellent hypnotic, especially useful in treating cases of nervous insomnia and excitability; also used to soothe whooping-cough. Dose as hypnotic 0.5—0.75 to 1.0 g, best dissolved in warm tea. Dose for whooping-cough: 0.05—0.1 g once or twice a day.

Veronese green see "MINERAL COLOURS".

Veronese yellow see "LEAD COLOURS".

Vesipyrin = phenylester of acetylsalicylic acid:



Good antirheumatic and bladder disinfectant. Single doses for adults 1.0 g, or 2.0—5.0 g per day; for children 0.5 g, twice or three times a day.

Victoria lac see "CELLULOID VARNISHES".

Vigorite see "DYNAMITE".

Vinegar. Essentially a dilute aqueous solution of acetic acid, obtained either by diluting acetic acid (see "ACETIC ACID") or by the acid fermentation (oxidation) of alcoholic liquids. The material used in the manufacture of vinegar is wine, weak brandy (less than 10 % alcohol) beer and beet sugar. The micro-organism causing the acidification is called *Mycoderma aceti*.

When the alcoholic liquids are left in barrels the formation of vinegar is very slow, consequently this method has been largely replaced by a more rapid one. A large surface of the liquid is exposed to the action of the air. There are various ways of achieving this; air is blown into the liquid, or the liquid is made to run over wooden shavings, &c., drop down from flat to flat through the air, or is thrown through the air by paddles. Ozone (q. v.) is said also to be used with great advantage.

For details see P. HASSACK, "GAERUNGS-ESSIG" (Vienna 1904, A. HART-LEBENS Verlag).

Vinegar is used for cooking purposes, for making pickles, &c.

See also LENZE, Chem.-Ztg. 1906, 1299.

According to Germ. Pat. 179847 various salts may be added which have a nutritive value and prevent the growth of micro-organisms. Such salts are:—Ferrous sulphate (0.1 %) and sodium and potassium phosphate.

Vinopyrine. A tartaric acid compound of p-phenetidine used in cases of headaches, &c.

Viscolane. A new ointment-base prepared from the bark of the mistletoe.

Viscose. A sodium salt of cellulose xanthate obtained by the action of carbon disulphide and alkali on cellulose. Cotton fibre is allowed to swell in alkalies or pine wood fragments are boiled with caustic soda lye under pressure; in both cases the resulting mash is treated with carbon disulphide. STEAR prepares viscose by treating 100 parts of cellulose for 24 hours with a 17.7 % solution of NaOH, pressing out the excess of solution until only three times the weight of the original cellulose is left, allowing this to stand in a closed vessel for 48 hours, then adding 75 parts of carbon disulphide and stirring the mixture for 5 hours. The product so obtained is exposed to the air to allow the excess of CS₂ to evaporate, after which it is stirred with a solution of 54 parts of NaOH in 300 parts of H₂O till a solution is obtained.

Viscose is soluble in water; solutions containing more than 1 % are gelatinous. The jelly can be made into moulds; it gradually shrinks and solidifies to a horn-like insoluble substance. Viscose on being warmed in solution to 60—80° separates in a form insoluble in water. Viscose in thin sheets is used as a substitute for glass and celluloid, and also as a dressing and thickening substance. It also serves as a partial substitute for resin glue in the manufacture of paper. All kinds of articles which are otherwise made of horn, ivory, celluloid, &c. can be formed from viscose. Viscose can also be easily acetylated and the solution of the acetate in chloroform can be used as a substitute for collodion. Viscose is an important material for the production of artificial silk. Compare "SILK". A great number of patents protect processes for the manufacture of threads from alkaline solutions of viscose, among others the Amer. Pat. 716778, French Pats. 323473, 323474, 343515, Engl. Pat. 16604 (1903), Germ. Pats. 152743 and 153817. The spinning is mostly carried out by passing the fluid jets issuing from the spinning pipes into a solution of an ammonium salt; a gelatinous viscose is first obtained, which afterwards becomes completely converted and hardened by heating in steam at 100° for 1 hour.

The purification of the raw product is of great importance for the manufacture of viscose into artificial silk. The process protected by Germ. Pat. 133144 is based on the fact that the salts of cellulose xanthate are not decomposed at ordinary temperatures by weak acids like acetic acid, lactic acid, formic acid, &c., while the by-products, alkaline salts of carbonic acid, thiocarbonic acid and sulphuretted hydrogen, produced by the action of CS₂ on NaOH can be removed by these acids. After treatment with the acids the cellulose xanthate is, precipitated by a dehydrating agent such as NaCl or alcohol, the leathery residue is washed with dilute NaCl solution or dilute alcohol and then beaten or pressed. The product, the technically pure viscose, is neutral and without colour or smell. It is the hydrated sodium salt of cellulose xanthic acid and dissolves readily and completely in water. Amer. Pat. 763266 employs sodium bicarbonate solution for the purification of viscose. See Germ. Pat. 183623 and Amer. Pat. 849822, 849823 and 849870.

Viscoid is a mixture of viscose with various other substances such as clay, powdered horn, zinc oxide, &c. Viscoid becomes as hard as ebony and can be turned and worked like this wood.

For the details of a process for the production of homogeneous mixtures of viscose with caoutchouc see Germ. Pat. 138511.

Vitriols. As a rule these are sulphates of heavy metals, e. g.:

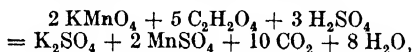
GREEN VITRIOL = ferrous sulphate. WHITE VITRIOL = zinc sulphate. BLUE VITRIOL = copper sulphate. Mixed (Salzburg) vitriol = cupric ferrous sulphate.

Vivianite see "MINERAL COLOURS".

Volumetric analysis. See also "ALKALIMETRY".

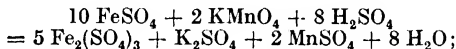
1. TITRATION WITH POTASSIUM PERMANGANATE. When compounds are oxidized with KMnO_4 in presence of acids the permanganate is converted into the corresponding colourless manganese salt. As the KMnO_4 solution alters easily it is prepared empirically by dissolving 3—3.5 g KMnO_4 in 1 litre of H_2O and the absolute amount of KMnO_4 in the solution determined with standard oxalic acid (see "ALKALIMETRY"). Free HNO_3 or HCl must not be present when titrations with KMnO_4 are carried out.

a) OXALATES. Render acid with H_2SO_4 , titrate with KMnO_4 until solution is colourless; the reaction is given by the equation



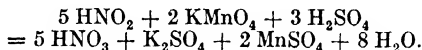
i. e. 5 mol. oxalic acid are equivalent to two mol. KMnO_4 .

b) IRON. A solution of ferrous sulphate is prepared by reducing ferric sulphate present by dipping a small zinc rod into the liquid rendered acid with H_2SO_4 ; titrate with KMnO_4 till a faint permanent pink is produced:

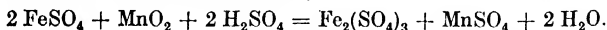


i. e. 1 mol. KMnO_4 is equivalent to 5 atoms Fe.

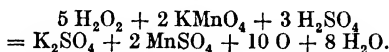
c) NITROUS ACID. Easily oxidized to HNO_3 by KMnO_4 , $2 \text{KMnO}_4 = 5 \text{HNO}_2$, according to the equation:



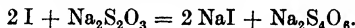
d) MANGANESE DIOXIDE. Cl evolved from MnO_2 and HCl is conducted into a measured vol. of titrated ferrous sulphate solution and the unchanged ferrous sulphate titrated with KMnO_4 :



e) HYDROGEN PEROXIDE. The solution is rendered acid with H_2SO_4 before titration:



2. TITRATION WITH IODINE. With sodium thiosulphate iodine is converted into sodium iodide and sodium tetrathionate:



A $\frac{1}{10}$ N standard thiosulphate solution is necessary for titration; this is obtained by dissolving 24.8 kg crystallized $\text{Na}_2\text{S}_2\text{O}_3$ (+ 5 H_2O) in 1 litre of water, the solution must be kept in the dark. Also an iodine solution is required: 12.7 g I are dissolved in an aqueous solution of 25 g potassium iodide in 900 g H_2O . 20 ccm of the thiosulphate solution are mixed with a little starch solution and then the iodine solution is run in until a permanent blue appears. The iodine solution is then diluted with the calculated amount of H_2O to make it equivalent to the thiosulphate solution.

As indicator a solution of starch or (with preference) of zinc iodide starch is used: 4 g of starch¹⁾ are heated to boiling point with 20 g zinc chloride and 100 g H₂O, then 2 g zinc iodide are added, diluted to 1 litre and filtered.

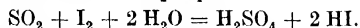
1 ccm $\frac{1}{10}$ N.-iodine solution = 0.0158 g Na₂S₂O₃.

1 ccm $\frac{1}{10}$ N.-thiosulphate solution = 0.0127 g I.

a) CHLORINE AND BROMINE. These are set free from their compounds and are then passed into KI-solutions; the I liberated is titrated with thio-sulphate.

1 ccm $\frac{1}{10}$ N.-thiosulphate = 0.00355 g Cl = 0.008 g Br.

b) SULPHUROUS ACID. This must be titrated in very dilute solution with iodine solution; it is oxidized to H₂SO₄;



1 ccm $\frac{1}{10}$ N.-standard-iodine solution = 0.0032 g SO₂ = 0.0041 g H₂SO₃.

c) SULPHURETTED HYDROGEN. This is best passed into iodine solution, forming sulphur and hydriodic acid (H₂S + I₂ = S + 2 HI); the iodine is titrated with thiosulphate solution.

1 ccm $\frac{1}{10}$ N.-iodine solution = 0.0017 g H₂S.

d) ARSENIOS ACID. The solution is rendered alkaline with sodium bicarbonate and is then mixed with a measured excess of standard-iodine solution: H₃AsO₃ + 2 I + H₂O = H₃AsO₄ + 2 HI. The excess of I is back titrated with thiosulphate solution.

1 ccm $\frac{1}{10}$ N.-iodine solution = 0.00495 g As₂O₃.

e) ARSENIC ACID. It is reduced with SO₂, the excess of the latter removed and the As₂O₃ formed titrated as in d.

1 ccm $\frac{1}{10}$ N.-iodine solution = 0.00575 g As₂O₃.

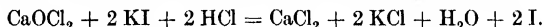
f) ANTIMONY OXIDE. This is oxidized with I like As₂O₃.

1 ccm $\frac{1}{10}$ N.-iodine solution = 0.0061 g Sb = 0.0073 g Sb₂O₃.

g) STANNOUS OXIDE. This is also oxidized like As₂O₃.

1 ccm $\frac{1}{10}$ N.-iodine solution = 0.0059 g Sn = 0.0067 g SnO.

h) HYPOCHLORITES. A weighed amount of the salt is dissolved in H₂O, or bleaching powder, mixed with water, diluted to 1 litre, well stirred and a definite part of the liquid transferred to a beaker. Potassium iodide solution is added, then HCl and starch solution. The liberated I is then titrated with thiosulphate. The reaction is given by the following equation:



1 ccm $\frac{1}{10}$ N.-thiosulphate solution = 0.002625 g HOCl = 0.00355 g Cl.

i) CHLORIC ACID. This is decomposed with HCl: HClO₃ + 5 HCl = 3 Cl₂ + 3 H₂O. The Cl is passed into KI-solution, starch solution is added, and titration effected with the thiosulphate solution.

1 ccm N/10 thiosulphate solution = 0.001408 g.

3. TITRATION WITH SILVER NITRATE. The standard solution contains 169.55 g AgNO₃ per litre, though only $\frac{1}{10}$ N.-standard solutions are used, prepared by dissolving 17 g AgNO₃ in H₂O in 1 litre. The silver solution must be kept in the dark and its strength re-determined for every experiment.

¹⁾ According to the report of Lunge to the Intern. Analyt. Committee (Congress for Applied Chemistry, Berlin 1903) a reliable water-soluble starch is the ozone starch of Karl Conrad, Kyritz. When dissolving this starch it must be boiled for some time; it then keeps in lightly covered bottles for 3—4 weeks. In passing from blue to colourless a violet shade is obtained.

This is done with a $\frac{1}{10}$ N.-sodium chloride solution containing 5.85 g NaCl per 1 litre. The indicator is a solution of 1 part yellow potassium chromate (K_2CrO_4) in 20 parts H_2O .

It is used in titrating salts of hydrochloric acid, hydrobromic acid and hydriodic acid, after the solution has been mixed with a few drops of potassium chromate solution. When all the halogen is precipitated a permanent reddish colour due to Ag_2CrO_4 appears. *The solution should be neutral.*

1 ccm $\frac{1}{10}$ N.-silver solution = 0.00355 g Cl = 0.008 g Br = 0.0127 g I.

In the same way silver itself is determined, by mixing the neutral solution with a measured excess of $\frac{1}{10}$ N.-standard sodium chloride solution: When all halogen is removed the excess is back titrated with silver solution.

1 ccm $\frac{1}{10}$ N.-standard sodium chloride solution = 0.108 g Ag.

4. TITRATION WITH AMMONIUM THIOCYANATE. The molecular weight of $\text{CHS} \cdot \text{NH}_4$ is 76, so that the $\frac{1}{10}$ N.-solution should contain 7.6 g thiocyanate. It is, however, not sufficient to weigh the calculated amount of salt directly; about 8 g ammonium thiocyanate are dissolved in H_2O to 1 litre, and the amount then determined with $\frac{1}{10}$ N.-silver solution. It is then diluted with the calculated amount of H_2O .

The indicator is a dilute aqueous solution of iron ammonia alum. When all Ag is separated as thiocyanate a blood-red colour due to the ferric thiocyanate appears.

Ammonium thiocyanate is used in titrating silver as well as halogens. The silver solution should contain much free HNO_3 (but no N_2O_3). Hg and large quantities of Cu should not be present.

1 ccm thiocyanate solution = 0.0108 g Ag.

For chlorine-, bromine- and iodine salts a known excess of $\frac{1}{10}$ N.-silver solution is added with the addition of a few ccm of iron alum solution and acidification with HNO_3 . It is then titrated with the thiocyanate without filtering; a yellowish brown colour indicates the end of the reaction.

In the same way solutions of cyanogen salts are titrated. In this case the AgCN precipitated must be filtered off, and the excess of silver back titrated in the filtrate.

1 ccm $\frac{1}{10}$ N.-silver solution = 0.0052 g CN.

5. TITRATION WITH URANIUM ACETATE (uranylacetate). The solutions used in this method to determine phosphoric acid are 1. sodium ammonium phosphate ($-\text{NH}_4 \cdot \text{NaHPO}_4 + 4 \text{H}_2\text{O}$) solution; 14.718 g of the salt are dissolved in 1 litre. 2. Uranyl acetate ($-\text{NO}_2 \cdot [\text{C}_2\text{H}_3\text{O}_2]_2$) solution. About 35 g are dissolved in 1 litre and adjusted to the sodium ammonium phosphate solution using potassium-ferro-cyanide solution as indicator. 3. Ammonium acetate solution. 100 g $\text{NH}_4 \cdot \text{C}_2\text{H}_3\text{O}_2$ and 100 ccm acetic acid (S. G. 1.04) are dissolved in 1 litre H_2O . For adjusting, 30 ccm of solution 2, are mixed with 10 ccm of solution 3, and 10 ccm H_2O , the mixture is heated in a water bath, titration with solution 1 to follow until a drop put on a porcelain plate with potassium ferrocyanide solution produces a brown-red colour. The uranium solution is then diluted until equivalent to solution 1.

1 ccm uranium solution = 0.005 g P_2O_5 = 0.0069 g H_3PO_4 .

When a phosphate solution is to be titrated, 40 ccm are used, containing not more than 0.15 g P_2O_5 ; 10 ccm of the ammonium acetate solution are added, titration following as above.

6. TITRATION OF SUGAR WITH FEHLING'S SOLUTION. FEHLING'S solution as a volumetric solution is not kept mixed. Two solutions are prepared:—

1. 34.64 g copper sulphate ($\text{CuSO}_4 + 5 \text{H}_2\text{O}$) are dissolved in 500 ccm of H_2O .
 2. 173 g potassium-sodium tartrate ($\text{KNaC}_4\text{H}_4\text{O}_6 + 4 \text{H}_2\text{O}$) and 50 g NaOH are dissolved in 500 ccm of H_2O . Immediately before use equal quantities of the solutions are mixed. 10 ccm of the mixture are heated with 50 ccm H_2O in a porcelain dish and standardized with a solution of 0.0475 g pure cane sugar in 10 ccm H_2O , inverted by warming with 1 ccm HCl to 70°C . The solution is diluted to 100 ccm and run into the boiling copper solution until the blue colour has entirely vanished. The concentration of the sugar solution should be such that it contains $\frac{1}{2}$ —1 % of grape sugar.

10 ccm FEHLING'S solution = 0.05 g grape sugar = 0.0475 g cane sugar.
 For further details see "INDICATORS" and "ALKALIMETRY".

Vulcanized fibres. Produced by passing pure paper through zinc chloride solution, washing and drying. It is very strong and can only be torn with difficulty. In appearance it is like the fresh skin of an animal. It is used when great hardness and strength are required, for instance for break blocks, small straps, rollers, boxes, &c.

Besides paper, vegetable fibres of various kinds have also been used. Parchmenting is partly caused by H_2SO_4 instead of ZnCl_2 . In all cases vulcanized fibre is produced under high pressure.

There are various kinds of vulcanized fibre, the chief difference being in the hardness and flexibility.

Vulcanizing see "CAOUTCHOUC".

W

Waggon grease. Thick or semi-liquid axle lubricants can be made either by hot or cold methods. As a rule however this class of article is made by heating oil of resin, paraffin oil or mineral oil residues, with a suitable addition of calcium hydroxide; the resin oil however must be in considerable excess of the other ingredients. The blue waggon greases are fatty substances in the natural state, the yellow are obtained by saponification with lye and an addition of palm oil.

This article is rendered cheaper by adding heavy spar or light spar, graphite or talc to as much as 50 percent. The waggon grease made with these adulterations is quite suitable for old waggons with worn axles and holes, as this substances adheres better to the surface and is not so easily pressed out of the holes as the pure fat. For good waggons, however, only the superior products should be used. These lubricants are made from fats and oils alone.

Walnut oil' see NUT OIL.

Washing see "CHEMICAL CLEANING".

Washing blue. A blue colouring matter which is added to washing or rinsing water to neutralize the yellow tint of cotton and linen goods. Blue is also added to dressing materials for the same purpose. Different kinds of colouring matters are used for this purpose, among which are ultramarine, Berlin blue, indigo carmine, aniline blue and smalt. Washing blue also usually contains starch, clay, gypsum, chalk, glycerine and others substances.

Washing powder. Usually consists of powdered Na_2CO_3 and about 5 % soap. Sometimes small quantities (less than 1 %) of turpentine and sal ammoniac are added.

Waste fats see "FATS AND OILS".

Water. H_2O .

REQUISITE CONDITIONS FOR DRINKING WATER.

According to F. FISCHER good drinking water should have the following qualities.

1. It must be clear, colourless and without smell.
2. The temperature at different seasons should only vary between 6 and 12° C.
3. It should contain but little organic matter and absolutely no organisms causing putrefaction.
4. It should contain no ammonia, no nitric acid and no large quantities of nitrates, sulphates or chlorides.
5. It should not be too hard, that is it should contain no large amount of magnesium salts.

WOLFFHUEGEL gives the following *desiderata*, from a hygienic stand point, for a good drinking water.

"The water must above all be absolutely free from toxic or infectious bodies. It should be clear and colourless, have a good taste and have no smell. The temperature should be refreshing and should be subject to no great variations in the course of the year. Organic substances should if possible be absent. The quantity of substances in solution should be within narrow limits, the organic contents should be as low as possible as also the contents of chlorides, sulphates and nitrates. It must be free from sulphuretted hydrogen. Underground water should show no signs whatever of ammonia and nitric acid. The hardness of the water should not exceed 18 German degrees and should contain neither magnesium salt nor gypsum in any appreciable quantity.

DESIRABLE CONDITIONS OF WATER FOR INDUSTRIAL PURPOSES.

The demands made by the different branches of industry as to the water they require are of very varied natures. In general good drinking water is suitable for factory use, still there are certain differences which have to be considered. For instances certain substances which do not affect the water for household use, render it useless for some trade purposes; on the other hand certain substances which render water disagreeable to drink may be advantageous for some factories.

1. WATER FOR STEAM BOILERS.

The water for this purpose should be as soft as possible, that is it should contain little chalk and in particular very little magnesia, to prevent formation of boiler crust. Should the water at hand therefore be hard it should be purified before being put into the boiler. Compare "WATER PURIFICATION".

It is important that water for boilers should be free from rust-forming ingredients, which destroy the metal. Waters containing large quantities of oxygen and uncombined or half combined carbonic acid form rust. Waters containing sulphuretted hydrogen or large quantities of ammonium salts are also harmful and should be avoided. Further the formation of rust is favoured by compounds containing chlorides. Of these magnesium chloride is especially dangerous. Condenser water containing oil is also unfit for feeding as there is a danger that under certain circumstances a ferro-calcium soap may form in the boiler, which spreading in a thin layer over the sides, prevents the water from reaching the metal and thus causes the sides of the boiler to wear out very quickly. Condenser water containing oil is, however, rendered harmless if the boiler is greased over with mineral oil.

DENSITY AND VOLUME OF WATER AT -10° TO $+100^{\circ}$.According to ROSETTI, taking 0° and 4° as units.

t	Density at $0^{\circ} = 1$	Volume at $4^{\circ} = 1$	Density at $4^{\circ} = 1$	Volume at $4^{\circ} = 1$
- 10°	0.998274	1.001729	0.998145	1.001858
- 9°	0.998556	1.001449	0.998427	1.001575
- 8°	0.998814	1.001191	0.998685	1.001317
- 7°	0.999040	1.000963	0.998911	1.001089
- 6°	0.999247	1.000756	0.999118	1.000883
- 5°	0.999428	1.000573	0.999298	1.000702
- 4°	0.999584	1.000416	0.999455	1.000545
- 3°	0.999719	1.000281	0.999590	1.000410
- 2°	0.999832	1.000168	0.999703	1.000297
- 1°	0.999926	1.000074	0.999797	1.000203
0°	1.000000	1.000000	0.999871	1.000129
+ 1°	1.000057	0.999943	0.999928	1.000072
+ 2°	1.000098	0.999902	0.999969	1.000031
+ 3°	1.000120	0.999880	0.999991	1.000009
+ 4°	1.000129	0.999871	1.000000	1.000000
+ 5°	1.000119	0.999881	0.999990	1.000010
+ 6°	1.000099	0.999901	0.999970	1.000030
+ 7°	1.000062	0.999938	0.999933	1.000067
+ 8°	1.000015	0.999985	0.999886	1.000114
+ 9°	0.999953	1.000047	0.999824	1.000176
+ 10°	0.999876	1.000124	0.999747	1.000253
+ 11°	0.999784	1.000216	0.999655	1.000345
+ 12°	0.999678	1.000322	0.999549	1.000451
+ 13°	0.999559	1.000441	0.999430	1.000570
+ 14°	0.999429	1.000572	0.999299	1.000701
+ 15°	0.999289	1.000712	0.999160	1.000841
+ 16°	0.999131	1.000870	0.999002	1.000999
+ 17°	0.998970	1.001031	0.998841	1.001160
+ 18°	0.998782	1.001219	0.998654	1.001348
+ 19°	0.998588	1.001413	0.998460	1.001542
+ 20°	0.998388	1.001615	0.998259	1.001744
+ 21°	0.998176	1.001828	0.998047	1.001957
+ 22°	0.997956	1.002048	0.997828	1.002177
+ 23°	0.997730	1.002276	0.997601	1.002405
+ 24°	0.997495	1.002511	0.997367	1.002641
+ 25°	0.997249	1.002759	0.997120	1.002888
+ 26°	0.996994	1.002014	0.996866	1.003144
+ 27°	0.996732	1.003278	0.996603	1.003408
+ 28°	0.996460	1.003553	0.996331	1.003682
+ 29°	0.996179	1.003835	0.996051	1.003965
+ 30°	0.99589	1.00412	0.99577	1.00425
+ 31°	0.99560	1.00442	0.99547	1.00455
+ 32°	0.99530	1.00473	0.99517	1.00486
+ 33°	0.99498	1.00505	0.99485	1.00518
+ 34°	0.99465	1.00538	0.99452	1.00551
+ 35°	0.99431	1.00572	0.99418	1.00586
+ 36°	0.99396	1.00608	0.99383	1.00621
+ 37°	0.99360	1.00645	0.99347	1.00657
+ 38°	0.99323	1.00682	0.99310	1.00694
+ 39°	0.99286	1.00719	0.99273	1.00732
+ 40°	0.99248	1.00757	0.99235	1.00770
+ 41°	0.99210	1.00796	0.99197	1.00809
+ 42°	0.99171	1.00836	0.99158	1.00849

t	Density at 0° = 1	Volume at 0° = 1	Density at 4° = 1	Volume at 4° = 1
+ 43°	0.99131	1.00876	0.99118	1.00889
+ 44°	0.99091	1.00917	0.99078	1.00929
+ 45°	0.99050	1.00958	0.99037	1.00971
+ 46°	0.99009	1.01001	0.98996	1.01014
+ 47°	0.98967	1.01044	0.98954	1.01057
+ 48°	0.98923	1.01088	0.98910	1.01101
+ 49°	0.98878	1.01134	0.98865	1.01148
+ 50°	0.98832	1.01182	0.98819	0.01195
+ 51°	0.98785	1.01230	0.98772	1.01243
+ 52°	0.98737	1.01279	0.98725	1.01292
+ 53°	0.98689	1.01328	0.98677	1.01341
+ 54°	0.98642	1.01377	0.98629	1.01390
+ 55°	0.98594	1.01426	0.98581	1.01439
+ 56°	0.98547	1.01475	0.98534	1.01488
+ 57°	0.98499	1.01524	0.98486	1.01537
+ 58°	0.98450	1.01574	0.98437	1.01587
+ 59°	0.98401	1.01625	0.98388	1.01638
+ 60°	0.98350	1.01678	0.98338	1.01691
+ 61°	0.98299	1.01731	0.98286	1.01744
+ 62°	0.98247	1.01785	0.98234	1.01798
+ 63°	0.98194	1.01839	0.98182	1.01852
+ 64°	0.98140	1.01895	0.98128	1.01908
+ 65°	0.98086	1.01951	0.98074	1.01964
+ 66°	0.98032	1.02008	0.98019	1.02021
+ 67°	0.97977	1.02065	0.97964	1.02078
+ 68°	0.97921	1.02124	0.97903	1.02137
+ 69°	0.97864	1.02183	0.97851	1.02196
+ 70°	0.97807	1.02243	0.97794	1.02256
+ 71°	0.97749	1.02303	0.97736	1.02316
+ 72°	0.97690	1.02365	0.97677	1.02378
+ 73°	0.97631	1.02427	0.97618	1.02440
+ 74°	0.97571	1.02490	0.97558	1.02503
+ 75°	0.97511	1.02553	0.97498	1.02566
+ 76°	0.97450	1.02617	0.97438	1.02630
+ 77°	0.97389	1.02681	0.97377	1.02694
+ 78°	0.97328	1.02745	0.97316	1.02758
+ 79°	0.97267	1.02809	0.97255	1.02822
+ 80°	0.97206	1.02874	0.97194	1.02887
+ 81°	0.97145	1.02939	0.97132	1.02952
+ 82°	0.97083	1.03005	0.97070	1.03018
+ 83°	0.97020	1.03072	0.97007	1.03085
+ 84°	0.96956	1.03139	0.96943	1.03153
+ 85°	0.96892	1.03207	0.96879	1.03221
+ 86°	0.96828	1.03276	0.96815	1.03289
+ 87°	0.96764	1.03345	0.96751	1.03358
+ 88°	0.96699	1.03414	0.96687	1.03427
+ 89°	0.96634	1.03484	0.96622	1.03497
+ 90°	0.96568	1.03554	0.96556	1.03567
+ 91°	0.96502	1.03625	0.96490	1.03638
+ 92°	0.96435	1.03697	0.96423	1.03710
+ 93°	0.96368	1.03770	0.96356	1.03782
+ 94°	0.96300	1.03844	0.96288	1.03856
+ 95°	0.96231	1.03918	0.96219	1.03931
+ 96°	0.96161	1.03993	0.96149	1.04006
+ 97°	0.96091	1.04069	0.96079	1.04082
+ 98°	0.96020	1.04145	0.96008	1.04158
+ 99°	0.95949	1.04222	0.95937	1.04235
+ 100°	0.95879	1.04299	0.95866	1.04312

SOAP SOLUTION NECESSARY FOR 100 ccm WATER WITH DIFFERENT DEGREES OF HARDNESS.

Amount of soap solution used	Hardness in German degrees	1ccm solution equals degrees of hardness	Amount of soap solution used	Hardness in German degrees	1ccm solution equals degrees of hardness
3.4	0.5	—	26.2	6.5	0.277
5.4	1.0	0.25	28.0	7.0	0.277
7.4	1.5	0.25	29.8	7.5	0.277
9.4	2.0	0.26	31.6	8.0	0.277
11.3	2.5	0.26	33.3	8.5	0.294
13.2	3.0	0.26	35.0	9.0	0.294
15.1	3.5	0.26	36.7	9.5	0.294
17.0	4.0	0.26	38.4	10.0	0.294
18.9	4.5	0.26	40.1	0.5	0.294
20.8	5.0	0.26	41.8	11.0	0.294
22.6	5.5	0.277	43.3	11.5	0.31
24.4	6.0	0.277	45.0	12.0	0.31

2. WATER FOR DYEING, PRINTING AND BLEACHING WORKS.

The water must be clear and colourless; iron has a very deleterious action. Hard water should also be avoided. Hard water is, however, advantageous for the process of spinning raw silk. For successful work with certain colouring matters, such as Turkey red, madder, alizarine, madder purple and others a certain amount of lime in the water is decidedly favourable.

3. WATER FOR BREWERIES.

The water should contain little organic matter, but above all no organisms causing fermentation. Water for brewing should be good drinking water and fulfil the conditions given by FISCHER as desirable for that purpose. Soft water is better than hard. Water containing much iron is not to be recommended.

4. WATER FOR DISTILLERIES.

The water should on the whole have the same qualities as for breweries. It should be soft, free from organic matter and organisms. A large amount of common salt is unfavourable for the germinating process, but the presence of magnesium chloride is still more unfavourable.

5. WATER FOR SUGAR FACTORIES.

The most harmful components in water for this purpose are nitrates, for they prevent from crystallizing six times the usual amount of sugar. Sulphates and the carbonates of alkaline earths are also unfavourable in this respect. A large amount of salt in the water is also to be avoided, for it decreases the value of the sugar by raising the amount of ash. Decomposing matter should be carefully avoided as under certain conditions it causes decomposition of the sugar.

6. WATER FOR STARCH FACTORIES.

For this purpose a very pure, colourless and clear water is necessary. It should contain very little organic matter and few micro-organisms, especially such as cause fermentation. Carbonates of the alkaline earths are harmful as they increase the amount of ash. Clay makes the starch grey and iron yellow. On the other hand it is said that a certain small quantity of sodium chloride in the water is favourable for the manufacture of starch.

7. WATER FOR PAPER FACTORIES.

Hard water is not suitable and water containing iron must on all accounts be avoided. Water with much organic matter as well as water with many micro-organisms tends to promote the growth of moulds in the paper.

8. WATER FOR TANNING.

The water should contain no great amount of organic matter as this causes decay of the leather. In summer the leather may even rot if the water is not pure in this respect.

The leather should be swelled in water that contains magnesium sulphate and in the second place calcium sulphate. Carbonic acid in solution has also a favourable effect.

Iron is not only of no detrimental effect, but is even often added for tanning purpose to give the "cut" of the leather a dark colour.

Water colours. The colours employed for water colour painting consist of finely powdered pigments, which are mixed, according to quality, with gum, dextrine, tragacanth, glue, glycerine or isinglass. Moist colours are also mixed with the juice of potatoes. Very fine glossy paints probably also contain a slight addition of wax, mastic, and Copaiva balsam. Besides the paints sold in dry cakes, water colours are also made to keep in a damp state, this variety is termed **MOIST COLOURS**. Moist colours are sold in two forms. One kind is very thick, of the consistency of dough, sold in rectangular stone-ware pots; the other kinds, sold in tubes like oil colours, have a jelly-like consistency.

With regard to the pigments used for the manufacture of water colours, it may be said that as a general rule they are the same as those used for oil paints. A preference however is usually given to transparent colours for ordinary water colour painting, although a branch of this art, gouache painting, is done in opaque colours.

The most durable water colours are made from mineral pigments. Compare "**MINERAL COLOURS**". Artificial mineral colours are as a general rule less durable. Vegetable and animal colours give paints which are remarkable for brilliancy and transparency, but none of them bear exposure for a lengthy period of time. Coal-tar colours are very seldom used in the manufacture of water colour paints. The prices of these paints vary very much, according to quality. Good artists' colours cost as a rule 5—6 pence for a small tube. This holds good however only for ordinary colours, rare paints such as madder lac, carmine, brilliant blue, ultramarine and others are dearer, the prices varying between 9 pence and 1/6.

Watergas. This is a gas mixture obtained by passing steam over red hot coal. It consists theoretically of 50 per cent by volume of hydrogen and 50 percent by volume of carbon monoxide. Its formation corresponds to the equation, $C + H_2O = CO + H_2$. In reality water gas contains on an average 3—5 % CO_2 and less CO . Nitrogen and sulphuretted hydrogen are also present.

The manufacture of water gas is carried out in generators containing coke or anthracite. One part of the material is burnt, thus heating the rest of the carbon to the necessary temperature (1000—1200°) for the conversion, and the steam is then admitted. Two generators are placed side by side. While in the one water gas is being produced by conduction over glowing coals, the contents of the other are heated by hot air. When the coals in the first generator have cooled to below 1000° and those in the second are heated to above this temperature, the process is reversed, air being conducted into the first and steam into the second. In this way the work can be carried on till the coal in the generators is exhausted; indeed with a suitable arrangement for charging the generators, the work can be carried on without intermission.

Care must be taken in practice, that the above-named worthless and harmful impurities bear only a minute proportion to the principal components. Above all the carbon dioxide should be prevented from being in excess, for which reason the temperature during the process must be kept very high. The lower the temperature, the more CO_2 is formed according to the equation $\text{C} + 2\text{H}_2\text{O} = \text{CO}_2 + 2\text{H}_2$. According to Germ. Pat. 153840 the yield of water gas is much improved by placing several layers of coals heated by hot air with layers at a lower temperature. This causes the steam and the gas to pass through layers of higher and lower temperatures in such a way, that before the gas leaves the generator a layer of the highest temperature has to be gone through. By this arrangement a gas is said to be produced which is rich in CO and contains very little carbon dioxide.

Water gas is purified as a rule by ferrous oxide, but this only removes the inorganically combined sulphur. To a certain extent also, the gas is also charged with iron-carbonic-oxide compounds, which are objectionable when the gas is used for lighting purposes. To remedy this a method of purifying water gas is protected by Germ. Pat. 159136. The gas freed from CO_2 is conducted in a heated condition through hot or glowing oxides, hydroxides, carbonates or silicates of alkalies, alkaline earths and earths, or through the oxides and hydroxides of iron and zinc to remove S and CN. A temperature up to 500° can be employed, which considerably hastens the reaction. It is recommended first to pass the gas through retorts filled with coke, indirectly heated, to reduce the CO_2 as far as possible to CO for the purpose of separating CO_2 from the product.

Apart from the careful purification to which the crude gas must be submitted, the value of the product depends on the quality of the material, that is, the coal. Formerly only very pure coals, such as anthracite and coke could be used; it has, however, lately been rendered possible to employ inferior fuel even with advantage for this purpose.

The value of the gas depends upon its use as a heating and lighting agent, since it produces an extremely high temperature on burning.

Water gas can be directly used only for heating purposes, as it burns with a very hot, but perfectly blue flame which gives little light. Indirectly, however, this gas can be advantageously made use of for artificial illumination as follows.

There are in fact two methods of doing this; first by heating incandescent bodies, such as WELSBACH's, in the water gas flame, or secondly, the water gas can be carburetted. The carburetting is carried out by loading the gas with the vapours of benzene or the residues from petroleum. The method of auto-carburetting, put forward by LEWES of London, deserves special consideration. The water gas is passed through the glowing gas retorts which are filled with coals and thus directly mixed with coal gas. Compare "COAL GAS". Water gas is a very cheap and excellent heating and lighting material which is coming more into use.

This gas has, however, one disadvantage. It has absolutely no smell, but at the same time it possesses extremely poisonous qualities, on account of the large proportion of carbon-monoxide.

The danger is avoided by adding strong smelling substances such as ethyl mercaptan.

DOWSON GAS, generator gas, mixed gas, semi-water gas are the names given to a product closely allied to water gas. It is produced by passing air and steam simultaneously over red hot coals. It is cheaper than water gas, but is inferior to it in heating power; it contains about 50 % of nitrogen and only 15–18 % of hydrogen and 25 % of carbon-monoxide.

Water glass. This substance is a glass in which the silicic acid is only combined with an alkali, not with alkaline earths or heavy metals. Compare

"GLASS". For this reason water glass is naturally very easy to melt, and dissolves readily in hot water.

Sodium silicate, which in its composition varies between $\text{Na}_2\text{O} \cdot 4 \text{SiO}_2$ and $\text{Na}_2\text{O} \cdot 2 \text{SiO}_2$, is the most important modification. It is obtained by fusing 45 parts of powdered quartz with 23 parts of calcined soda and 6 parts of charcoal in a furnace, or in a glass maker's crucible. The melted substance is cooled, broken up, powdered and treated with hot water. The result is usually tinged with green owing to the presence of Fe. Water glass in solution is also made by digesting infusorial earth or amorphous or precipitated silica with strong caustic soda lye.

Potassium silicate is obtained by fusing 45 parts of quartz sand, 30 parts of potash and 25 parts of carbon. Besides these, there are two other kinds of water glass, which are combinations of these, and which are known under the names of double water glass and fixative water glass. The latter is a saturated potassium water glass with SiO_2 , to which is added a certain quantity of sodium water glass containing a very high percentage of alkali.

French Pat. 325164 aims at an improvement in the manufacture of this article. A mixture of silica and the sulphates or carbonates of the alkalies is heated with addition of carbonaceous substances in an electric resistance furnace. An alkaline chloride can also be added to the mixture of silica, alkali sulphates and carbon, and then heated in a furnace.

The various solutions of water glass are decomposed by CO_2 with separation of SiO_2 . Potassium water glass dissolves readily in H_2O . Potassium water glass powdered and mixed with water swells into a jelly and hardens in 2 to 3 days to a strong glass-like mass. It is used as an adhesive under water. It also serves for impregnating sandstone, for the manufacture of artificial stones, for fireproofing, and as a weighting material in the soap industry, &c. Water glass is also a useful article in dyeing, textile printing, paper making and in stereochromy.

Water glass:

Willy Manger, Dresden, Germany.

Waterproofing of textiles. There are many different methods in use for this purpose, which may be broadly classed in the following five groups.

A. A thin, coloured syrupy paste is spread in several layers over the material; the paste consisting of half raw and half boiled linseed oil, mixed with mineral colouring matter. The material must be dried between the application. The process takes place with simultaneous addition of siccatives, resin in benzoline, &c.

B. The materials are put through a dilute solution of paraffin in benzine. Dilute solutions of tars and fats in benzine are also used in the same way for impregnating goods.

C. The materials are treated with glue or gelatine, and afterwards with tannin, or they are impregnated with chromege latine, which is rendered insoluble by exposure of the material to the light.

D. The materials are soaked in fatty solutions of soap, metallic mordants and metallic soap are then formed on the material, thus rendering it waterproof. Acetate of alumina is used as a mordant, and fat, resin and wax should be mixed in the soap and water.

E. The materials are impregnated with solutions of cautchouc.

Space does not permit mention of the details of the methods of waterproofing, nor of the numerous patents which deal with this subject. A few words, however, may be added on the most recent patented methods. According to Germ. Pat. 137216, cautchouc, guttapercha, balata, or the residues or regenerated products of these substances are mixed with soaps made from elaidized or non-elaidized fats or sebacic acids, which are insoluble in water.

These form plastic substances which wear well and are suitable for waterproofing and impregnating textiles, paper, &c., as well as for making leather cloth, imitation leather, wall papers, floor covers and so on. The following materials can also be added to different mixtures of this kind, cellulose, viscose, celluloid, oils, fats, resins, glycerine, fibrous materials of all kinds, albuminous bodies, colouring matters and metallic salts, &c. Germ. Pat. 141411 protects a method for waterproofing materials without destroying their porous nature. The material is steeped in a solution of aluminium acetate, dried and then again put in a solution of wool fat, or lanoline, dissolved in a volatile solvent. Sugar of lead in solution can also with advantage be added to the aluminium acetate.

The method protected by Germ. Pat. 147029 is characterized by the treatment of the materials or articles with a dressing of roots of the *Amorphophalli*, more especially of the genus *Conophallus*; and of such other bodies of which the solutions are suitable for forming waterproof elastic coatings, such as caoutchouc, caoutchouc lac and the like. The two groups of mixtures can be applied either simultaneously or one after the other. The light, cheap amorphophallous mixture makes the material air tight and does not mildew, while the caoutchouc renders it waterproof.

According to Germ. Pat. 165201 the goods are mordanted in the usual way and then treated in a boiling solution of resin soap. One side is then treated with wax-like materials and the other side with an adhesive, e. g. para gum.

According to Germ. Pat. 166350 the material is treated with a hot emulsion of ammonium salts of fatty or resin acids insoluble in water, and fats, waxes and solid hydrocarbons, and then after splitting off the ammonia from the salts, dried and finally ironed or calendered.

Suppl. Germ. Pat. 179698 combines this process with the dyeing of the vegetable textile fibres.

The following account of the manufacture of waterproof textiles is taken from an article by S. EISENSTEIN, Allg. Chem.-Ztg. 1905, p. 507. Cloth materials are soaked in a tub containing aluminium acetate of 5° Bé for twelve hours, taken out, dried, and finally aired at a temperature of 60—65° C. Carriage aprons, sails, tarpaulins &c. are saturated with a 7 % solution of gelatine at 40° C, dried, in the open air, then put through a 4 % solution of alum, again air dried, rinsed and finally once more dried.

Cotton, linen, jute and hemp textiles are first treated in a bath of ammoniacal copper oxide of 10° Bé at a temperature of 25° C, till they are quite saturated, they are then put into a solution of caustic soda of 2° Bé and finally dried. A solution of aluminium sulphate may with advantage be employed instead of caustic soda as this renders the material still more impervious to water.

White and light coloured textiles are first put through a bath (4—5° Bé) aluminium acetate at a temperature of 40° C. The material is then freed from the excess of liquid by being passed through a wringer, after which it is washed in a solution of 5 kg of good Marseilles soap in 100 kg of soft water. The materials are then drawn through a 2 % solution of alum, dried for 2 to 3 days on frames, after which the soap particles left unabsorbed are removed by brushing machines. Another method for cotton materials is the following: 1.5 kg of gelatine are dissolved in 50 litres of boiling water, to which is added 1.5 kg of grated tallow soap and 2.5 kg of alum. The bath is then cooled down to 50° C, when the cotton textiles are put through, dried and calendered.

Cellulose materials are rendered waterproof by impregnating with a warm solution of 1 kg of gelatine, 1 kg of glycerine and 1 kg of tannin in 12 kg of wood vinegar (12° Bé).

Linen, hemp, jute, cotton and other materials can be rendered waterproof and at the same time free from odour by impregnating with the following

compound, and then putting several times through a brushing machine. This latter process dries the material by brushing, makes the texture visible, smooths the fibres and gives a special gloss. The materials made of natural and dyed cotton by the usual methods, are passed through the bath of water-proof dressing, which is made of 30 kg of Japan wax, 22.5 kg of paraffin, 15 kg of resin soap, 35 kg of starch and 5 kg of a 5 % solution of alum. The first mentioned components are melted in a boiler, then the starch is added, and finally the alum and the whole well stirred up together. It is asserted that materials treated in this way do not lose their colour, do not stain other fabrics (i. e. do not "bleed"), are perfectly water proof and have absolutely no smell. An excellent substance for renewing waterproof textiles, consists of a solution of 0.5 kg of gelatine and 0.1 kg of potassium bichromate, or chrome alum and 0.1 kg of acetic acid. The latter being added to prevent the solution of glue from becoming gelatinized. The above named substances must be dissolved in 3—5 kg of water, and to this is added 0.5 kg of ammoniacal copper oxide (10^0 B6). These preparations are simply brushed on to the materials and allowed to dry in the air.

Water, Purification of. A distinction must be made between the methods suitable for the purification of water for household use, and those which serve for the purification and improvement of water on a large scale. Also the methods of purifying water to be used for human consumption differ from those used for water for industrial purposes.

A. PURIFICATION OF DRINKING WATER.

Filtration is of great importance as a method of purifying drinking water. House filters are all made on the principle of driving the water by pressure through some porous material which retains the substances in suspension. Among these mention may be made of the carbon filters containing bone charcoal, BREYER's micromembrane filters containing asbestos, PIEFKE's asbestos cellulose filters as described below, CHAMBERLAND's filter with burnt porcelain earth and BERKEFELD-NORDTMEYER's filtering candles of calcined infusorial earth, &c. All these filters give satisfaction, however, only for a time; sooner or later they become choked up, or they allow of the passage of micro-organisms and have to be cleaned. Central water filtration is carried out by sand filters, sometimes open and sometimes covered; the covered method in which the above-mentioned PIEFKE filters are used is preferable.

In the case of sand filtration, a filter is formed of different layers of sand 1.5 to 6 metres deep. This method was first used in England, and was first introduced into Germany at the end of the first half of the last century. According to KROEHNKE the filtering substance is so constructed that from the bottom of the flat masonry reservoirs to the top there is a series of graduated layers, the lowest consisting of stones the size of the fist while above are others becoming gradually smaller until at the top there is fine-grained sand. The heaviest stones lie at the bottom; each layer serves to support the one above it, thus entirely preventing any danger of the upper layers collapsing. The depth of the single layers differs considerably in different cases. V. ESMARCH gives the following average depths for the single layers of a sand filter.

- | | |
|--|---------------|
| 1. Stones 60—200 mm diameter | 250 cm depth. |
| 2. Coarse gravel 30—60 mm round | 150 " " |
| 3. Medium gravel 2—30 mm round | 120 " " |
| 4. Fine gravel 10—20 mm round | 8 " " |
| 5. Coarse sand 3—4 mm round | 5 " " |
| 6. Fine sharp sand, 0.5—1.0 mm round | 60—150 " " |

All the material should be carefully sifted so that the size of the single stones or grains are of equal size. The material must be perfectly pure, that is free from organic matter, and must also be well washed before being put in the reservoir. The upper layer alone can be regarded as the filter proper, therefore the absolute purity increases in proportion to its depth.

The filter is first filled the reverse way by letting in the water at the bottom and continuing until the water stands 1 metre above the top layer of sand. After 24 hours water is then allowed to enter from above and the out-flow opened. The filter is not quite efficient for some time after its construction — not until a thin deposit of the finest particles is formed on the surface of the coarser particles.

This layer gradually increases in thickness and thus very gradually stops up the filter, when it must be regenerated by renewing the top layer.

Sand filters were for a long time considered the best arrangements for central water purification. They were, however, in no way perfect. Indeed it is proved that under certain circumstances pathogenic bacteria can also pass through the filter. If properly regulated, it is true, this can very rarely happen, but on the other hand the danger increases that the water, passing too rapidly through the filter, exceeds the prescribed limits of 125 mm per hour. The rate of movement of the water in the filter should not be greater than 125 mm an hour = 3 m a day, 3 cbm of water a day require a filtering surface of 1 sqm. Still greater is the danger when the contents of the sand filter freezes, which often happens during the winter months, causing cracks and openings in the sand layer, through which impurities can easily pass.

Undoubtedly the fine asbestos cellulose filters of the new type introduced by PIRFKE possess great advantages over the sand filters. In these filters the filling material is composed of a preparation of a very fine-fibred mixture of asbestos and cellulose, of which even a very thin layer forms an extremely close and dense filter. The filter itself consists of a large number of filtering chambers with sieved bottoms. The fibrous material is washed into the chambers by water, where it settles in a compact layer. After it has been for a long time in use, the material is again flooded out by a counter current of water and cleaned in a washing cylinder, after which it can be again employed.

Other constructions of the same system work with shaped and pressed asbestos cellulose cakes. The asbestos-cellulose system works most excellently and is very economical and practical.

PIRFKE has worked out a method founded on the asbestos-cellulose filtering principle, for the removal of iron from water by first separating the dissolved iron as $\text{Fe}_2(\text{OH})_6$, by bringing the water into intimate contact with air in an apparatus specially constructed for the purpose, and filled with suitable material. The $\text{Fe}_2(\text{OH})_6$ is then separated from the water by filtration through asbestos-cellulose.

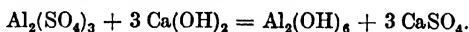
The chemical purification of water is carried out by adding lime, which precipitates the bicarbonates of the alkaline earths and also Mg and Fe, at the same time causing other impurities to settle.

Clarification is also much used in water works. The impurities are allowed to settle in the clarifying vessels, the process of sedimentation being assisted when necessary by the addition of some precipitating agent.

For the above purpose many different compounds serve as precipitating agents, which either form of themselves flaky precipitates which carry the floating impurities down with them or which precipitate only on the addition of a second agent to the water.

Of these agents, mention may be made of the salts of aluminium, manganese, and magnesium in combination with lime, chalk, soda, &c. Most frequently a mixture of alum, or aluminium sulphate with calcium hydroxide is probably

used, as is indeed the case for instance, in the clearing works at Frankfurt a. M. In this case the reaction runs as follows



The loose precipitate of aluminium hydroxide in this case carries the substances in suspension down with it.

Two compounds are not in all cases necessary to bring about the precipitation. For instance, in water containing suspended calcium carbonate, the precipitation of aluminium hydroxide occurs on simply adding salts of aluminium.

Care must be taken in making use of these or other reagents, that the quality of the water in other respects does not suffer. For instance, water which is rendered clear by precipitation of aluminium sulphate and lime is rendered harder by the gypsum which is then present in solution. The above mentioned method of precipitation, the artificial production of a precipitate for the purpose of causing the suspended impurities in the water to settle with the added chemicals is termed indirect precipitation. Direct precipitation is, however, carried out when the precipitate itself consists partly of the material to be removed from the water and partly of the agent. Direct precipitation is used for separating calcium and magnesium salts in solution, for rendering the water free from iron, and also at times for the removal of humic substances. If the water contains much iron, this must be removed to render it fit for drinking or dyeing purposes. For this purpose the water is subjected to the action of air in some suitable way, as for instance by passing it over heaps of coke or irrigation works, which causes the iron in solution as bicarbonate to separate in the form of FeCO_3 and $\text{Fe}_2(\text{OH})_6$. Filtration following this process, completes the operation. Compare above remarks on asbestos-cellulose filters.

Germ. Pats. 145797 and 154792 make use of filters which are partly filled with finely distributed manganese oxide for removing iron contents. Germ. Pat. 148404 considerably assists the removal of the iron by previously increasing the amount of alkali.

The purification of water as well as of sewage by the electric current has recently attained considerable importance. In this process, either ozone is developed, or the chloride in the water is decomposed, so that chlorine and hypochlorites are formed, which in their turn destroy the microorganisms in suspension. The ozone is generated by electricity in SIEMENS and HALSKE's specially constructed apparatus, and passes from the bottom to the top of a tower in which the water trickles down in finely distributed particles. The water is put through a filter previous to this operation, the filter used being that invented by KROEHNKE, the so-called RAPID. Compare also the article on "OZONE". The ozone apparatus used in this case is SIEMENS' plate apparatus (12000 volt). One pair of plates with 1 sqm. of electric surface requires 0.5 HP.

The purification of water by means of ozone will probably become more popular.

The sterilization of water by chlorine and hypochlorites electrolytically prepared has been proposed by HERMITE. He decomposes sea water or a salt solution by the electric current and mixes the sterilizing fluid thus produced with the water to be purified. The fluid has been given the name of HERMITE. Compare "BLEACHING". The HERMITE process at first caused great excitement, but many drawbacks have been discovered, which prevent the practical adoption of this method.

Distillation as a method of purifying water only comes into consideration for large quantities in cases where it is necessary to procure fresh water from sea water.

PURIFICATION OF FEED WATER FOR BOILERS.

The water for feeding boilers must be of such a kind as will not damage the boiler and does not require excessive expenditure of fuel. The principal point to be observed is that the water must not form any incrustation or sediment of Ca and Mg salts. The incrustations are the separations inside the boilers caused by the increased concentration of the solution by heat. In this way the bicarbonates of the alkaline earths, Mg and Fe are converted with evolution of CO into neutral, insoluble carbonates, while CaSO_4 separates out by reason of the increasing concentration. $\text{Fe}_2(\text{OH})_6$, SiO_2 , organic substances, fatty acids from the lubricating mixture, &c., help to form deposits. These incrustations are very bad heat conductors and consequently cause a larger consumption of fuel. They also cause the heat to be spread around the sides of the boiler very unevenly, thus often leading to explosions, &c.

The methods used for preventing the formation of deposits may be classed under headings of mechanical and chemical preventives. Of the first the most effective is to keep the boiler as free from sediment as possible, by frequently pumping air through it and smearing the sides with grease, petroleum, &c. Mineral oils such as petroleum can be added to the water without fear of damage, indeed these oils may be said to prevent directly the formation of incrustation; other oils and fats however should not be admitted for they become dissociated by the pressure and high temperature of the boiler with formation of fatty acids. These acids settle on the sides of the boiler in coatings of varying thickness, and, besides not being good heat conductors, they also eat into the metal.

The chemical methods for the prevention of such incrustations are based on the principle of rendering the water as soft as possible. The feed water is treated with chemicals such as barium chloride, magnesia, caustic alkalies, nitric acid and so on. More popular and perhaps more practical for this purpose are, however, soda and lime. The soda precipitates the CaSO_4 as insoluble carbonate and the lime, in the form of slaked lime, or lime water decomposes the bicarbonates. The feed water can also be purified with soda alone, but in this case the water must at the same time be warmed, so that the Na_2CO_3 precipitates the gypsum, while the bicarbonates are decomposed by the heat. Feed water is now as a rule purified before it enters the boiler, only such water being used as has been cleared by settling or by being passed through a filter. A point to be carefully noted, is that a smaller amount of chemicals will be found necessary if the water is heated before their addition.

Barium carbonate has lately been highly recommended, but its use renders necessary a special alteration of the ordinary precipitate receiver. The purification of the feed water with this chemical will also be found considerably more expensive than with Na_2CO_3 .

The value of all systems for purifying water will however always remain illusory if the result of the process is not subject to continual chemical control.

C. PURIFICATION OF REFUSE AND SEWAGE WATER.

The purification of the refuse water from factories is treated of in the article on "SEWAGE". In this article the purification of town sewage will be considered.

The best method for the purification of town sewage is undoubtedly the irrigation system. The sewage is conducted on to fields specially laid out for this purpose, the so-called sewage farms. The sewage trickles through the ground and is filtered by passing through the upper layers of the ground, leaving behind the organic contents and reaching the drain pipes under-

ground in a purified condition. The sewage farms act excellently if the ground is suitable, the management good and the area sufficient. This is splendidly illustrated by the success of the Berlin sewage farms. It is true the results are less satisfactory from an economical point of view, though from that of hygiene there is nothing better to be desired.

In the second place the purification of sewage water by means of chemicals should be considered. The same chemicals are used as mentioned above for the purification of drinking water under A.

Special mention should here be made of the ROTHE-DEGENER HUMUS PROCESS which must be classed as a combination of mechanical and chemical methods. This process is an improvement on that of ROTHE-ROECKNER in which the water mixed with the chemical precipitating agents, usually lime and aluminium sulphate, slowly rises through a clearing well. The ROTHE-ROECKNER tower consists of a lever bell and a clearing reservoir arrangement, and by its construction economizes to a considerable extent the amount of building ground. The slime deposit however from most clearing methods is a disadvantage also shared by the ROTHE-ROECKNER system. The deposit is very watery and of very little use either for agricultural or industrial purposes, and its removal is difficult and expensive.

The ROTHE-DEGENER process does away with this disadvantage. The purification of the sewage is carried out by a humus in the form of lignite or rather old peat moss, which is added to the sewage, with the result that the impurities are at once absorbed. For the purpose of clearing, suitable metallic salts, such as ferric sulphate, or aluminium, or magnesium sulphates, &c. are added. The sewage which is converted by the humus and solution of salts after passing a mixing apparatus reaches the ROTHE-ROECKNER clearing cylinder. The slimy sediment of this operation is freed from the greater part of its water in a vacuum drying apparatus, and forms a substance similar to peat, which is then cut up and dried in the air, or directly made into briquettes, which prove to be a very good fuel.

Another process for the purification of sewage water is the so-called bacterial method. It is based on the vitality of certain micro-organisms which decompose the organic compounds of sewage water. Filtering beds of gravel or coke serve as the "seat" of these purifying bacteria. These beds are so numerous that they can be put out of use alternately for some hours. After the filters are filled with the sewage, the latter is allowed to stand for two hours, when the organic contents are oxidized by the bacteria. The sewage is either put directly into the beds or is first treated for 24 hours in so-called rotting chambers. The biological method is much used in England, but in Germany it is still in the experimental stage. It is however a most promising system for the purification of drainage.

Other methods for the purification of sewage which are strongly recommended are the OZONE process and the HERMITE process, which are both alluded to under A: PURIFICATION OF DRINKING WATER.

Water Purification:

Hans Reisert G. m. b. H., Köln, Germany.

Water distilling apparatus:

Friedrich Heckmann, Berlin SO, 16, Brückenstr. 6b (see advt.).

Volkmar Haenig & Comp., Heidenau-Dresden, Germany (see front part advt.).

Water sprays.

These are used for producing water and other liquids in the form of a fine spray. They are constructed in such a way that the liquid is kept in motion by the action of a screw and is forced to leave in a finely-divided state.

For chemical industries apparatus of glass is generally used in order to withstand the action of 1. Acids, 2. Alkalies, and to absorb acid gases with water (the latter being in a finely-divided state); the body of the apparatus is generally made of glass the screw of hard rubber (vulcanite), lead or other resistant material.

Water sprays:

Paul Lechler, Stuttgart, Germany.

Wax. The waxy fatty acid esters do not belong, like the real fats to the glycerines, but to the monovalent cetyl, ceryl, myricyl alcohols, &c. Compare "FATS". Most waxes are solids. To this class belong bees' wax, insect or tree wax, spermaceti and carnauba wax. Spermaceti oil is however a liquid wax. See "SPERMACETI" and "VEGETABLE WAXES". Insect wax, Chinese tree wax (*Cera chinensis*) is obtained from the shell louse which inhabits some Chinese trees, and is of little importance for European markets. The so-called Japanese wax and myrica wax are as a matter of fact fats akin to tallow. See "VEGETABLE TALLOW". What is generally understood under the name of wax and is at the same time the most important kind is obtained from the honeycombs of bees, called beeswax. The comb is melted in hot water or steam and the crude wax thus obtained separated from its impurities, honey, pollen and the like by boiling several times with water, when the foreign substances either pass into the H_2O or settle in a layer between the wax and the water. This wax is of a yellow to dark brown colour and is bleached by exposure to the sun. Chlorine is not used on account of its deleterious action. The process of bleaching is carried out by first melting the yellow wax in steam and letting it flow through narrow slits on to a circulating roller which is half under water. The wax thus solidifies into narrow thin strips, which offers the largest possible surface to the light, and in this condition it is then laid in the sun. The bleaching process can be hastened by an addition of turpentine oil, or instead of sun-bleaching the wax can be treated with $K_2Cr_2O_7 + H_2SO_4$.

Under the name of wax extract a product is sold obtained from the refuse of the honeycomb press by extraction with benzine.

Yellow beeswax has a S. G. at 15° of 0.962—0.966. Its melting point is $62-64$ and it solidifies at 60.5° . Saponification number 87.8—96.2; iodine number 8.3—11. White beeswax comes on the market in round cakes; it is harder than yellow wax. It has a S. G. at 15° of 0.964—0.968, a melting point of $63-64^\circ$, a solidifying point of $61.5-62^\circ$; saponification number is 90.4—91.4.

Wax is employed in the manufacture of candles, for dressings for fabrics, for making waxed paper, plasters, ointment, and as a modelling substance in the plastic art, &c.

According to Amer. Pat. 735538, artificial wax is produced by mixing ketones of the acetone group with excess of paraffin, or with paraffin and stearin, with or without the addition of ceresine.

Compare also the articles on "OZOKERITE", "CERESINE", "VEGETABLE WAX" and "MINERAL WAX".

Wax, vegetable (PALM WAX): The most important member of this class of wax is Carnauba wax, *Cera Carnaubae*. See the article on "Wax". It is found in small scales on the upper surface of the leaves of the Carnauba palm, *Copernicia cerifera*, and consists principally of the myricyl ester of cerotinic acid. It is solid S. G. at 15° 0.990—0.999. M. P. $83-91^\circ$ and it solidifies at $86-87^\circ$. Saponification number 79—93. It is used for making candles,

wax varnishes and so on. Tree wax is the name given to a substance made of a mixture of 120 g of yellow wax, 270 g of purified resin, 60 g of thick turpentine, 15 g of tree oil and 15 g of fat; it is used for covering wounds on the trunks and branches of trees. Another method of making this product is to melt together 40 parts of pine resin, 15 parts of yellow wax, 15 parts of Japanese wax and 3 parts of tallow, then adding 24 parts of common turpentine and a solution of 0.2 parts of curcuma extract, dissolved in 0.8 parts of spirits of wine. Fluid tree wax is obtained by slowly melting 0.5 g of pine resin with 150—220 g strong alcohol with continual stirring.

Japanese wax and myrica wax will be found under the heading "TALLOW, VEGETABLE".

Weld, wold see "DYERS WEED".

Welding. The autogeneous soldering or welding of metals by means of the oxyhydrogen flame is becoming very important. It is termed autogeneous welding, because fluxes, hammering, pressure are necessary.

The oxy-hydrogen flame has a temperature of 1900° C; the metal therefore immediately melts and the welding takes place automatically. The two pieces to be welded do not need to be polished before hand, as the flame itself reduces any impurity. The work is easy to learn, is not exhausting or trying and is accomplished with absolutely no danger to health.

By this method welding can be carried out and finished off in a way not possible by any other process.

The use of compressed gas in cylinders is for this purpose decidedly preferable to electrolytical generation.

Westfalite see "SAFETY EXPLOSIVES".

Westrumite see "MINERAL OILS".

White tanning see "MINERAL TANNING".

Wine. Alcoholic beverages which are produced by the fermentation of fruit juices containing sugar. In a narrow sense under the term wine is understood, the fermented juice of the grape, *Vitis vinifera*. The grapes are first made into a mash either simply by treading, pulling through a grape mill, or by treatment in box-shaped apparatus specially made for this purpose. The box treatment serves also for separating the berries from the acid-containing stem.

The mash is then put into spindle or lever presses to separate off the juice. For making red wine, the mash of berries from which the stems have been removed is first fermented and then pressed; the alcohol thus obtained extracts (under pressure) the colour from the blue and red berries.

The must is fermented in two stages, the first and more violent principal fermentation, which takes 3—14 days, and the "still" fermentation of the new wine, which lasts longer and is carried on at a lower temperature.

After the second process is sufficiently advanced the wine is racked into large closed barrels made of oak and stored in cool cellars till ready for bottling. Many chemical changes take place during the time of storage and maturing. Different esters are formed from the fatty acids, and also fusel oils, which serve to bring out the bouquet or aroma. In consequence of the evaporation of alcohol during storage the contents of the barrels diminish. It is therefore necessary to add more from time to time, as otherwise micro-organisms may develop which would spoil the wine. The maturing of the wine is hastened

by frequent rackings. The wine is cleared and brightened with albumen, kaolin, gelatine, isinglass, gypsum, &c. The law only allows of wine being improved ("doctored") by GALL's method of sweetening, CHAPTAL's method for the same purpose and finally by mixing different brands together after fermentation. Most kinds of wine are mixed with different sorts of must or new wine. The "sugaring", CHAPTAL's method, serves to improve a must which contains too much acid. The acid is neutralized by adding pure calcium carbonate and then sufficient cane sugar, to bring it up to the normal sugar content. GALL's method of sweetening is also used for improving an insufficiently sweet must. Sugar and water, or a pure solution of sugar is added till the must shows a normal content of 24 % of sugar and 0.65 % of acid. GALL's method is of the greatest importance, for in this way, the sour must of bad years which will not ferment of itself, can be made into wine. The law does not permit the addition of alcohol to wine, neither is it permitted to add glycerine except under specified conditions. GALL's method is also only legal within certain limits. A modification of sugaring whereby gypsum instead of calcium carbonate is used to neutralize the must is a questionable method as the gypsum in the wine tends to become converted into potassium bisulphate.

The different kinds of sweet wines are in a certain sense artificial. They are produced by fermenting the grape skins with sugar and water. Sparkling wines are also mostly made in the same way.

The manufacture of artificial wine from spirit, syrup, sugar, glycerine and fruit ether with cheap fruit wines is forbidden by law.

Wintergreen, oil of. An aromatic, essential oil obtained from *Gaultheria procumbens*. Usually it is obtained synthetically (see "SALICYLIC ACID ESTERS"). It is used in the preparation of fruit essences, for perfuming soap, &c.

Witherite = barium carbonate. A heavy powder. S. G. 4.30. Sparingly soluble in water, readily in HCl.

Wood. The increasing value of wood as a material on the one hand and its liability to damage under unfavourable circumstances on the other have caused the preservation of wood to become a very important industry.

1. **DRYING.** After the wood has lain for about a year, so piled up that the air has free access around and between the logs, it is carted to a shed for further drying, and finally put into a hearth. These furnaces are fed with special fuel, and the hot gas which reaches the wood must be cooled to 150° C. It is also important that the drying in these furnaces should be done very gradually as otherwise the wood will split or warp. The empyreumatic vapours produced by the partial consumption of the fuel are at the same time antiseptic. To increase the resistance to external influences the dried wood is brushed over with linseed oil, tar, oil paint or the like.

2. **EVAPORATION.** The sap present in the wood contributes greatly to its destruction, on account of the ease with which it becomes decomposed. Sometimes the wood is soaked in water to draw out the juices. This however is a troublesome process, and as a rule, it is preferable to steam it, that is the wood is treated with steam in suitable vessels. The work is carried out either in enclosed iron apparatus with steam pressure, or simply steamed in wooden vessels. In the latter case the steaming must be continued for 60—72 hours. The product is however less satisfactory than that produced by steam pressure.

3. **CHARRING.** By this process the moisture on the surface is absorbed, and the micro-organisms and organic substances which are liable to decompose are destroyed. At the same time the wood becomes impregnated with tarry

matters. The charring is done by holding the block in a fire. It is more practical to carry out this work however by movable flames from a blow pipe.

4. **IMPREGNATION.** There are various methods for this excellent way of preserving wood. The work is done with or without pressure. The mixture employed is made of corrosive sublimate (HgCl_2), oil of tar, copper sulphate, aluminium sulphate, sodium aluminate, ferrous sulphate, zinc chloride, mixtures of ammonia, sulphite and borate of ammonium, &c. **CARBOLINEUM** (q. v.) has proved to be a specially good tar oil. Creosote, vaporized and melted naphthalene, crude petroleum, and iron oxide are also used for this purpose. Impregnation with pressure is carried out either by forcing the fluid through the wood, or the wood is heated, the air removed by pumps and the impregnation fluid run in under pressure. For impregnation with heavy tar oils, the great aim is to heighten the effect of the oils by rendering them either soluble in water, or at any rate capable of forming an emulsion. The oils are rendered soluble by sulphonation, the emulsion is made with the assistance of soaps, and the fact that it is possible to make emulsions of oils which are insoluble in water with an extremely small quantity (about $\frac{1}{2}\%$ of soap) has become of great importance, not only for the purpose in question, but also for the manufacture of solid forms of spirits, benzene and sal volatile, &c. Mention must be made of a few of the more important new patents. Germ. Pats. 139441 and 152179 protect the manufacture of a durable emulsion of tar oil and zinc chloride solution for impregnating wood. According to Germ. Pat. 118101 and 150100 an impregnating mixture is made of a hot solution of the zinc or magnesium salts of naphthalene- β -sulphonic acid, &c.

5. **METALLISATION.** In this process the wood is impregnated with two solutions of salts one after the other, which combine in the fibres forming an insoluble precipitate. The wood is soaked in a solution of a zinc or copper salt, and afterwards with a solution of resin soap. Another plan is to soak in calcium chloride and sulphate, with barium sulphide and ferrous sulphate, with calcium chloride and water glass (sodium silicate).

GAUTSCHE'S method of impregnation for the purpose of rendering wood fireproof has proved of great service. The air is removed in a vacuum boiler, in which the fluid consisting of sulphate and ammonium borate is then introduced under pressure. The wood is not boiled, the temperature being only raised to 50°C . This kind of impregnated wood does not catch fire, nor can it spread fire, for it only chars to a depth of one centimetre and then remains like any other incombustible substance. GAUTSCHE'S impregnation process is protected by Germ. Pat. 152006.

Mention should also be made of HASSELMANN'S impregnation method, where the wood is boiled under pressure in solutions of iron and copper salts. According to Germ. Pat. 162043, sodium silicate (water glass) is coagulated by a solution of strong NaCl , the jelly is redissolved in NaOH and this mixture is used for painting the wood.

A quite new process is the method of impregnating wood with a solution of sugar. This operation is said to be a very successful method. The wood is boiled for several hours in open vessels with the solution of sugar, and then dried in hearths. During the process of drying the water evaporates, while the sugar solidifies amongst the wood fibres. By this treatment the firmness and durable strength of the wood is greatly increased. It also serves as an excellent preventive of mildew and rot.

Preservation of wood:

C. A. Peters Ltd., Derby London, Liverpool.

Wood dust mills:

Max Friedrich & Co., Leipzig-Plagwitz 17.

Wood, artificial. A substance having the appearance of wood made from fine shavings bound together by suitable adhesives. The adhesives used for this purpose are blood, solutions of glue, starch, aluminium sulphate, &c. A new modification, which seems very promising, has come on the market under the name of Xylolith. It is a mixture of shavings and magnesium chloride. This patent invention unites the advantages of wood with those of weather proof stones. Xylolith is used for flooring, panneling, carved ornaments, stairs, window sills, break blocks and many other purposes.

Wood ashes see "ASH".

Wood fibre. Compare "CELLULOSE". Ordinary wood fibre is not chemically pure cellulose, neither is it obtained by the action of chemical agents on the wood, but by purely mechanical methods.

Only those woods, which have long fibres, are suitable for the manufacture of this product. The kinds of wood which come into question are those of the coniferæ, poplars, and birches. In the manufacture of this article, there are five different stages to be gone through. 1. Preparation, 2. Pulping, 3. Sorting, 4. Drying, 5. Bleaching. The wood is prepared by removing the twigs and nuts and peeling off the bark. The wood is then torn into fibres by pressure against a large rotating grindstone, of about 1.3 m diameter made of sandstone, which turns at the rate of 150—200 times per minute. The pulped material is put into a sorting apparatus, fitted with a cylinder or frame sieve, which separates the coarser splinters and fibres from the fine substance. This coarse material is then ground in a mill. The pulp, after the water has been drained off, can be immediately used for the manufacture of paper. Compare "PAPER". If the fibre pulp is to be stored or transported, it is then dried in a sieve machine. This machine is a combination of pieces of felt and cylinders. The pulp leaves the machine as a moist dough-like substance, which if necessary can be still further dried by heat. If the pulp is to be bleached, which is in fact a difficult and only partially successful operation, it must be done while the material is still moist. The best agent for this purpose is sulphur dioxide. If the wood is treated by steam pressure before pulping, a part of its contents, the pure cellulose, becomes dissolved and the brown pulp, which has longer, more hairy and more flexible fibres than ordinary wood pulp, is obtained. This can then be manufactured into goods for which the ordinary pulp is not suitable, such as paper, leather paper, and so on without the addition of rags. One cubic metre of pine wood yields 300—350 kg of air dry white fibre or 250—300 kg of air dry brown fibre.

Wood gas. This gas used for lighting is obtained from resinous wood such as pine, by distillation in retorts. The gas is freed from its impurities in condensation apparatus and scrubbers, and dried in lime cleaners. Compare "COAL GAS". • Wood gas has the advantage of being comparatively pure, that is it contains no ammonia or sulphur compounds. Wood gas is very similar to that made from peat.

Gas manufactured from wood is only of importance in very well wooded districts, where the transport of suitable coal is very expensive, except in such cases, where it is a secondary product in the production of some other substance. In the same way the manufacture of peat gas is confined to certain districts.

Wood material see "WOOD FIBRE".

Wood oil. Oils of varying kinds obtained from trees growing in Further India and Java. Some are obtained from the stem and others by pressing the seeds.

The Chinese oil is obtained from the nuts of the TUNGSHU tree (*Elaeococca dryandra*), belonging to the *Euphorbiaceae*. The fruits, which are almost as large as oranges, are dried and then heated until the rind splits when the kernel can be easily removed. The kernels are then ground and pressed. The clear oil which is at first liquid and yellow, soon becomes viscid. When boiled it becomes brown or black. When freshly prepared it is very poisonous.

It is a viscid, cloudy mass with an unpleasant smell, and is used in the manufacture of varnishes, &c. There are two kinds: one dark and one yellow.

According to Engl. Pat. 5789 (1903) a substance suitable for the manufacture of linoleum is obtained by mixing heated Chinese wood oil with linseed or other drying oil, or with resin oil. Resin, siccatives, &c. may also be added.

Wood naphtha :

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Wood panels and blocks see "WOOD, ARTIFICIAL".

Wood spirit see "METHYLALCOHOL".

Wood stains. Very different kinds of stains are made use of for colouring wood. Some of the stains are put on cold, some on the other hand must be hot. Very frequently the desired shade or tone is only acquired after several treatments with two different stains. Wood stains are sold both as solids and liquids. In the former case they are dissolved either in warm water, or in alcohol 1 : 15.

Wood tar. This substance is obtained as a by-product during the process of charcoal burning by the condensation of tar. At the bottom of the stack at the lowest point a pipe is inserted to conduct the tar into the receiver. Wood tar is also obtained in the form of a condensed product of distillation in stack furnaces and crucible furnaces. This product separates after standing for some days into tar and wood vinegar. Compare "CHARCOAL", "CHARCOAL BURNING" and "ACETIC ACID".

Wood tar differs according to the material from which it is made. The tar made from ordinary wood is oily, while that from conifer wood is syrupy and sticky. The colour varies between light brown and deep blue-black. If wood tar is distilled, light and heavy tar oils are both obtained besides other secondary products. The light oil is used as a substitute for turpentine and the heavy oils for the manufacture of machine oil. Compare also the article on "CREOSOTE".

TEST. The analysis for distinguishing the different kinds of wood tar is carried out according to ED. HIRSCHSOHN in the following way.

I. Acetic acid (95 %) completely dissolves:

- a) French turpentine oil dissolves completely. The petroleum ether sample of the tar on being shaken with dilute copper acetate solution 1 : 1000 becomes greenish. Chloroform and absolute ether dissolve completely PINE TAR.
- b) Turpentine oil dissolves but little. The petroleum ether sample with copper acetate solution does not change colour. Chloroform and ether dissolve completely BIRCH TAR.

II. Acetic acid (95 %) dissolves completely:

- a) Turpentine oil dissolves completely.
 1. Aniline dissolves completely. The tar water (1 : 20) gives with a dilute solution of Fe_2Cl_6 (1 : 1000) a red colour JUNIFER TAR.

2. Aniline dissolves incompletely. The tar water with a dilute solution of Fe_2Cl_6 (1 : 1000) gives a red colour BIRCH TAR.
 b) Turpentine dissolves completely. Benzene, chloroform, ether and olive oil dissolve incompletely ASPEN TAR.

Wood tar:

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Wood vinegar see "ACETIC ACID".

Wool. The hair of different kinds of sheep. Most breeds of sheep are crossed with the Spanish merino, which is known for its excellent wool. The wool is prepared by first washing in water and then boiling in soap, water-soda, &c., to free it from the fat. The fat is also frequently removed by extraction with carbon disulphide, or other chemicals which dissolve fat.

Germ. Pat. 143698 protects a method for removing the fat by first subjecting the wool to the action of hot fat solvents, pressing out the excess of solvent by mechanical means, washing in hot water to remove the last traces of the chemicals and finally pressing out the water by machinery. All these operations are carried out one after the other in the same vessel. The employment of heated solvents separates not only the fat from the wool, but also what is known under the name of yolk and suint. If these are not removed, the water which is afterwards poured into the vessel to remove the remaining solvents would combine with these chemicals and with the yolk to form an emulsion. This emulsion would then not only prevent the water from penetrating the mass of the wool, but also seriously hinder the further cleansing of the product.

According to Germ. Pat. 155744 wet wool can be separated from the oil by benzine, by subjecting the raw material to previous treatment with a salt or acid solution.

Germ. Pat. 144485 and 146845 aim at making wool less sensitive to the action of alkalies. For this purpose the wool is treated with the vapour or a solution of formaldehyde. The wool subjected to this treatment can stand hotter and stronger solutions of alkalies in washing, bleaching and dyeing, &c. The second patent slightly modifies this method by subjecting the wool fibres to the action of a solution of formaldehyde, to which is added the alkali with which the fibrous material is to be treated later, or the wool fibre is put into a weak alkaline formaldehyde solution and then heated.

The washed wool, which in some cases has already been bleached with SO_2 , is then carbonized before being dyed. By carbonization is understood the removal of vegetable substances, such as burrs or straw. For this purpose the wool is soaked in hydrochloric or sulphuric acid, or aluminium chloride solution, beaten out into the so-called carbonization furnace, where the material is then dried by currents of air at a temperature of about 45° , and finally carbonized by further heating to $75-80^\circ$. After this operation the vegetable matter falls to dust and can easily be shaken and beaten from the wool fibres, which are entirely unaffected by this treatment. The carbonization can also be carried out with hydrochloric acid gas. This is sometimes done at the normal and sometimes at a higher temperature. The former method is considered on the whole to be the better. Carbonization is of special importance for the manufacture of shoddy, felt and artificial wool. The materials used for making these substances are old clothes and rags of pure wool or mixed goods. From these mixtures the vegetable fibres, cotton, &c., are removed by carbonization.

Mohair is made from the hair of the Angora goat, and cashmere from that of the Cashmere goat, while alpaca, vigogne and llama are made from the hair of different kinds of goats.

TEST. On the subject of qualitative testing and distinguishing from other textile fibres, see the article on "TEXTILE FIBRES".

Wool dyeing. Animal fibres have a greater affinity for most colours than plant fibres. For this reason wool can often be dyed by simply putting the fibres, from which the fat has been removed, while still wet into the cold or slightly warmed colour bath, and gradually increasing the temperature. This method of substantive wool dyeing is carried out with basic dyes, acid colours, benzidine dyes, &c. The temperature of the bath is usually 25–30° C, and this is gradually increased to boiling point during the process of dyeing.

Many kinds of colouring matter require the use of mordants for dyeing wool. There are four kinds of adjective wool dyeing possible.

1. **THE TWO BATH METHOD.** The wool is first heated with mordants and then dyed. Mordants of aluminium and chromium with tartaric acid, H_2SO_4 , and tin salts are used, and the process is carried out in a boiling bath in which the fibres must remain until cold. The wool is then rinsed, put into the warm dye bath and heated to boiling point. This most popular method of wool dyeing is used when such materials as wood extracts and alizarine dyes are used.

2. **THE ONE BATH METHOD** is carried out by putting the material into a bath composed of the materials given above for the double bath. This method saves time and work, but can only be used when the colour lake is partly soluble in the hot or acid bath. These kinds of colour lake include cochineal and chloride of tin, fustic and alum, fustic and tin salts, logwood and sulphate of copper, &c.

3. **AFTER-MORDANTING.** The wool is dyed first and the colour afterwards fixed by a mordant.

4. **THE THREE BATH METHOD** is generally used for dyeing wool black with logwood. The wool is first treated with a mordant $K_2Cr_2O_7$, then dyed in a logwood bath and finally the colouring matter, which is only mechanically absorbed by the fibres and not yet combined with the mordant, is fixed in a second $K_2Cr_2O_7$ bath. In other cases the third bath serves to make the colours brighter. This process is called brightening.

The wool is dyed either spun, unspun, or woven. The dye is faster if the wool is coloured while in the fibre, and yarn takes the colour better than cloth. On the other hand the unspun wool can only be treated with very pure colouring matters, such as will not interfere with the numerous later operations in the manufacture of cloth.

Compare also the article "VATS AND VAT COLOURS".

Wool fat (*Adeps lanae*). This substance is obtained by soaking the raw wool in water and washing with soap and carbonates of alkalies. The water is then treated in a centrifugal apparatus, which removes the grease from the soapsuds.

Sometimes the fat is removed from the wool by extraction with petroleum, ether or carbon disulphide. The product obtained is a greasy disagreeable substance with a colour varying from brown to yellow, the S. G. at 15° C is 0.937 and the M. P. 39–42.5° C. It is for the most part a mixture of cholesterine with the ceryl ester of cerotinic acid, cholesteryl ester of palmitic acid and cholesteryl ester of stearic acid. If the product is distilled, a mixture of cholesterine and uncombined fatty acids, the so-called distilled wool fat is obtained.

According to Germ. Pat. 143567 the fat can be mechanically extracted from the wool by the dust of infusorial earth, clay or chalk by means of a beetling apparatus. The value of this process however appears to be very questionable.

According to Germ. Pat. 155744 the soap and other emulsion materials, left over from the first washing of the wool, are mixed with solutions of NaCl , $\text{Na}_2\text{SO}_4 \cdot \text{HCl}$ or H_2SO_4 , whereby they are rendered insoluble in benzene, and from which the grease can be then extracted without the formation of an emulsion. It is however very doubtful whether the wet wool can be saturated with the benzene.

The disagreeable smell of wool fat is now removed by various methods.

The purified wool fat known under the name of lanoline is a product of considerable importance. The raw material is purified by different methods. The impurities can be extracted by means of boiling acetone or treated with benzene or some other fat solvent, after which the purified fat is obtained by distilling the solution. Another method is to add concentrated salt solution to the solution of fat, which facilitates the separation of the wool fat from the residue. The wool fat is treated either before or after purification with alkalis to remove the fatty acids; the soap then formed is dissolved in alcohol, while the purified wool fat remains behind. This is finally melted and kneaded with water. The white ointment thus obtained, which contains 25 % of H_2O , is the pharmaceutical product known as lanoline. It does not readily saponify and does not therefore become rancid. It can absorb up to 110 % of H_2O without losing its consistency. The principal reason for its extended use in the manufacture of ointments is the facility with which it is absorbed by the skin. Lanoline is distinguished from ordinary fats in that the fatty acids are combined not with glycerine but with cholesterine and fatty alcohol. According to Germ. Pat. 163254 and Suppl. Pat. 178804 lanogene, a variety of wool fat, can be separated by letting the wool fat stand over bone charcoal. The lanogene is absorbed and can be extracted with alcohol or with benzene containing 5—10 % alcohol. The product is capable of taking up large quantities of water (even if mixed with 98 % paraffin ointment).

X

Xanthate, potassium see "CARBON DISULPHIDE".

Xanthorhamnine see "PERSIAN BERRIES".

Xeroform = bismuth tribromphenol. $\text{Bi}_2\text{O}_3 \cdot \text{OH} \cdot (\text{O} \cdot \text{C}_6\text{H}_2\text{Br}_3)$. Obtained by the action of bismuth chloride or bismuth nitrate on sodium tribromphenolate.

Odourless, tasteless yellow powder insoluble in H_2O and in alcohol. Taken internally as an intestinal antiseptic; used externally as a substitute for iodoform in the treatment of wounds and diseases of the skin.

Xylenes and xylidines.

1. XYLENES (dimethylbenzenes). $\text{C}_6\text{H}_4(\text{CH}_3)_2$. Three isomeric liquid hydrocarbons occurring in crude benzene (see "BENZENE" and "COAL TAR"). Xylene is separated by fractional distillation though the separate isomeric xylenes can not be obtained in the same way. They are separated by a rather involved process based on the different behaviour of o-, m- and p-xylene towards dilute HNO_3 , concentrated H_2SO_4 and fuming H_2SO_4 respectively. All three xylenes are colourless liquids and boil between 137 and 142° C; industrially the most important isomer is m-xylene, used in the preparation of various tar colours.

2. XYLIDINES (amidoxylenes). $\text{C}_6\text{H}_3(\text{CH}_3)_2 \cdot \text{NH}_2$. A mixture of xylidines obtained by nitrating crude xylene and then reducing the nitroxylenes thus formed. This mixture contains 4 of the 6 isomers, the largest proportion

being as m-xylidine ($\text{NH}_2 : \text{CH}_3 : \text{CH}_3 = 1 : 2 : 4$) and p-xylidine ($\text{NH}_2 : \text{CH}_3 : \text{CH}_3 = 1 : 2 : 5$). Germ. Pat. 139457 discussed under "ANILINE" has been rendered available for the preparation of xylidines. — For some purposes the industrial xylidine may be used as it is, for others a separation is necessary, m-xylidine being the most valuable. There are several methods of separation, mostly patented and based on the difference in solubility of m- and p-xylidine acetate, of m- and p-xylidine hydrochloride and finally on solubilities of xylidine-sulphonic acids (or of their sodium salts). The best method for obtaining pure xylidines is to use pure xylenes.

m- and p-xylidines are colourless liquids which soon turn yellow in the air. m-xylidine S. G. 0.9184 (at 15°), B. P. 212° C; p-xylidine S. G. 0.980 (at 15° C), B. P. 215°.

Xylolith see "WOOD, ARTIFICIAL".

Xyol. A new disinfectant containing formaldehyde. Xyol is a clear liquid which turns milky on pouring into water. It has strong bactericidal properties.

Y

Yeast. Cells of the yeast plant which belongs to the family of the *Saccharomycetes*, a substance which brings about alcoholic fermentation, that is the decomposition of the sugar into alcohol and carbonic acid. The cells are round, oval or roller shaped and about 0.008—0.01 mm in greatest diameter. The cells propagate by branching or budding. Yeast is usually classed under two heads: beer yeast or barm and brandy yeast, which when pressed into a solid is known as German yeast.

The two varieties of yeast of the same origin are known as top and bottom yeasts. In appearance they can scarcely be distinguished. The upper yeast ferments fluids containing sugar very powerfully at 18—25° C, with the formation of a thick froth in which the yeast itself is borne to the surface. The fermentation by ground yeast goes on between 4 and 12° C slowly, the yeast itself remaining at the bottom.

Yeast is found in all kinds of places, so that fermentation takes place in every suitable solution.

As however other kinds may be present and may have an injurious action, e. g. in giving a bitter taste to the product or rendering it cloudy, artificial yeast is usually preferred in practice, especially for breweries and distilling works; the pure cultivated yeast, that is composed of one kind of cell, and produced by isolation culture, being the kind chosen.

The yeast now used in breweries is produced in special institutions, in special yeast propagation apparatus. Very large breweries prepare their own yeast. Different kinds of yeast are used for different kinds of beer thereby giving the beverage its special character. Similar experiments which have of late been successfully carried out with wine, encourage further attempts in the same direction.

For distilleries also, a special kind of yeast is cultivated by preparing a nutritive substance of green malt and other materials and subjecting the mash to a lactic acid fermentation. The acidification which is carried out in chambers heated to about 50° prevents the development of the numerous other micro-organisms which would be injurious. The mash when sufficiently acid is cooled as rapidly as possible to 15—20° and then impregnated with mother yeast. The artificial yeast thus grown is used, without separating the yeast and sour mash, for fermenting the mash of the still, some being retained as mother yeast for a new supply. Artificial lactic acid can be added instead

of developing a lactic acid fermentation. Compare "ALCOHOL". According to Germ. Pat. 123437 artificial yeast is prepared without lactic acid fermentation by using either sulphuric acid or phosphoric acid.

German yeast or dry, pressed yeast is very much employed at present especially for baking, in which industry it has almost entirely superseded the old fashioned barm. Head yeast (distillery yeast) is skimmed off, together with the fermentation froth and pressed to squeeze out the water. It is obtained by making a mash of rye and maize, sometimes also buck wheat and barley, adding sugar with kiln dried malt; subjecting this to lactic acid fermentation at about 50°, cooling after 24 hours to about 17° and finally fermenting with mother yeast. When the fermentation is sufficiently advanced, that is when the yeast is ripe, the froth is placed in a reservoir. After this the treatment depends on whether the mash has been fermented with the malt husks or whether these were first removed. In the latter case air is conducted through the mash during fermentation.

If the yeast froth still contains spent grain, or husks, or in fact any residue it is conducted after being mixed with H_2O into a sieving machine which separates these. The yeast is then washed and made into cakes in filter presses. The air yeast process mentioned above is however far better than this so-called residuary method. The fermented mash is allowed to settle in basins, and after the yeast has sunk the wort is skimmed off. The yeast is washed several times with H_2O , then passed through the filter press and formed into cakes.

According to a lecture given by LANGE at the International Congress for Applied Chemistry, held in Berlin in 1903, it is possible to produce an excellent yeast from dried potatoes mashed under steam pressure, having the same aroma, colour, vitality of growth and keeping properties as any other.

According to Germ. Pat. 173231 from a clear mixture of potato and beet juice, free from germinating matter, a yeast of good fermenting power can be obtained in the following way. The washed potatoes are made into a paste and from this the juice is obtained free from starch, by centrifuging. This is then mixed with beet juice similarly prepared, the whole acidified with H_2SO_4 , sterilized by boiling and filtered. The clear pale yellow liquid can then be used as a culture medium for the yeast plant. See also Suppl. Germ. Pat. 180594 and Germ. Pat. 174864.

TEST. BAU has worked out a method for proving the presence of ground yeast in pressed yeast based on the fact that the two sugars melibiose and melitriose cannot be directly fermented. The experiment is carried out by introducing into each of three test tubes 10 ccm of a 1 % solution of melitriose and 0.4 g of the sample yeast to be examined. The mouth of the tube is stopped with cotton wool and put in a germinating chamber at a temperature of 30° C. Pure head yeast splits the melitriose by means of a particular enzyme, called by BAU the melibiase, into laevulose, glucose and galactose, and these three sugars are then fermented. After 24, 48 and 72 hours one of the tubes is taken, the contents filtered and 3 ccm of the filtrate mixed with 1 ccm of FENLING's solution in a test tube and placed for 5 minutes in boiling water. If the fluid in the tube which has been standing for 24 hours remains blue, more than 10 % of yeast is present in the sample. If the same appearance is manifested by the tube which has stood 48 hours then it may be assumed the sample contained 5 % of ground yeast. If the fluid only becomes blue after 72 hours, about 1 % of ground yeast is present. Experiments by SAARE and BODE have shown that even the complete spoiling of a yeast has no influence on the surety of the test of ground yeast being present in pressed yeast, when carried out after BAU's method, provided the presence of ground yeast is only assumed as sure when the BAU method shows over 10 %.

Yeast food:

E. S. Spencer Ltd., Drummond Works, Drummond Road, London S.E.

Yeast extracts. The methods by which these extracts are produced are almost all patented and are all similar in principle. The yeast is well washed, after 12 hours the water is drained off and the product put into bags and pressed. The cells are burst open by boiling in an open vessel in a steam bath. The liquor is then evaporated *in vacuo* after being filtered.

The following special methods may be mentioned. According to Germ. Pat. 134165 the yeast is treated with H_2O , acidified with methylsuccinic acid (25 g per hectolitre), then with 5 % NaCl solution and finally washed with H_2O , to obtain the cell fluid of pressed yeast. The yeast is freed from as much water as possible, warmed 7—8 hours to 72—92° C and evaporated. A clear filtrate is obtained if cooling is avoided during treatment. The yeast extract is either dry or in the form of a thick syrup.

AUBRY's process (Germ. Pat. 120360) seems to be much used. The well washed and dried yeast which has passed through the press, is mixed with 5—10 % NaCl which renders it liquid and at the same time prevents auto-fermentation which would cause the development of evil-smelling by-products. The fluid is then allowed to stand for a time at a low temperature, digested for 2—3 hours at 50° C and quickly brought to boiling point, or the substance is put into the same amount or double the amount of boiling water and after boiling for 1—2 hours is pressed. The liquid is evaporated till a film of salt is formed and is then put aside in clearing vessels to settle. If allowed to stand some time in the air the taste of the product is improved. Germ. Pat. 134721 treats of the separation of the cell contents from the pressed damp yeast by ether vapours, benzene, toluene, chloroform, acetone, glycerine, methyl alcohol, but not ethyl alcohol. Germ. Pat. 151561 protects a process for the separation of the albumen of the yeast extract.

Amer. Pat. 785733 and 785734 treat of the preparation of yeast extract by the use of ethyl acetate.

Various other processes for the preparation of yeast extracts must be here passed over. These extracts are much used especially as substitutes for meat extract to which they are very similar in appearance, taste and also in the method of employment.

Germ. Pat. 157626 protects a method for removing the bitter taste that most yeast extracts possess. An oxidizing agent is used for the purpose, that is the extract is boiled with H_2O_2 . Ozone and peroxides can also be used.

For details on the yeast oil or fat used in medicine, compare "CEROLEINE".

TEST. The following is a method published by A. SEARL for proving the presence of yeast extract as an adulteration in extract of meat.

13 g of copper sulphate and 13 g of sodium tartrate are dissolved in 125 ccm H_2O , and at the same time 16 g of NaOH in 125 ccm H_2O . Both solutions are then mixed; 0.65 g of yeast extract in 46 ccm of H_2O is added to one-half of the above mixture and boiled 1—2 minutes. Pure extract of meat forms no precipitate, whereas if yeast extract is present a small quantity of a coagulated precipitate of a bluish-white colour is formed.

SEARL afterwards modified his method as follows; 3.24—6.5 g of extract are dissolved in 4—8 ccm H_2O and as much alcohol as precipitates the whole into an insoluble sediment. The sediment is dissolved in 46 ccm H_2O , filtered, and then treated further as given above. If yeast extract is present the characteristic bluish-white sediment will separate on boiling with the copper sulphate solution, and can then be collected and weighed. It is asserted that with this test as small a quantity as 1 % of yeast contents can be proved.

M. WINTJEN in Arch. f. Pharm. 1904, 507 gives another method for testing extract of meat for yeast adulterations. It is based on the fact that the filtrate from the albumen, salted out with zinc sulphate, will remain perfectly clear with extract of meat, whereas if yeast is present it will be clouded. The test is carried out by treating 20 g of extract solution with 2 ccm dilute H_2SO_4 and salting out with ZnSO_4 powder. After standing for 24 hours it is filtered, pouring the first drops back. A mixture of 20—30 % yeast extract in the extract of meat renders the fluid filtrate decidedly cloudy.

Ylang-Ylang oil see "ORCHID OIL".

Yohimbine. An alkaloid obtained from the bark of the African Yumbchoa (Johimbehe) tree. It is the methyl ester of yohimboic acid. It is taken internally with success for sexual impotence.

Ytterbium. Yb. A. W. = 173. A metal of the rare earths possessing like its compounds no industrial importance.

Yttrium. Y. A. W. = 88.9. A metal of the rare earths occurring as silicate in the mineral gadolinite. The oxide is easily separated from other oxides in consequence of its solubility in potassium bisulphate. As yttrium oxide Y_2O_3 emits an intense yellow light at comparatively low temperatures, yttrium compounds are frequently used in the manufacture of incandescent light mantles, e. g. yttrium chloride YCl_3 , yttrium nitrate $\text{Y}(\text{NO}_3)_3$, yttrium sulphate $\text{Y}_2(\text{SO}_4)_3$ &c. Yttrium compounds are much used in the manufacture of NERNST lamps.

Z

Zinc. Zn. A. W. = 65.41. Of the numerous zinc ores the following are especially important: calamine or zinc spar ZnCO_3 , and zinc blende ZnS , also flinty calamine (flinty zinc ore) $\text{Zn}_2\text{SiO}_4 + \text{H}_2\text{O}$, and willemite Zn_2SiO_4 .

The ores are first roasted, which in the case of calamine is very easy but with zinc blende is very difficult. The roasted ore, which consists principally of ZnO , is reduced by being heated with ground charcoal. The reduction is carried out at a temperature at which Zn volatilizes so that it distils off from the reduction vessels and can be collected in suitable receivers. The reduction and distillation take place either in tube-shaped retorts of fire clay which lie in the furnaces in several rows above each other (Belgian method), or in large muffles (Silesian method). The Zn collects in the iron receivers; it still contains numerous impurities especially, Pb and Fe, and also Cd, As, Sb, Bi, Ag, and Cu. If the Zn is obtained from blende it also contains S.

Recently magnetic preparation has become more and more important for the zinc industry (see article "PREPARATION OF ORES"). The original apparatus of WETHERILL has been modified in various ways; this apparatus is used for the separation of zinc ores from iron ore. At any rate the discovery of WETHERILL viz. that of using very strong magnetic fields — has rendered the smelting of slightly magnetic minerals possible.

Germ. Pat. 149161 treats a process for the separation of zinc blende and pyrites which depends on the comparatively greater readiness of oxidation of the pyrites compared with zinc blende. The iron is converted into ferrous sulphate by a kind of artificial weathering and can then be removed by extraction. According to the Suppl. Germ. Pat. 151770 the mealy powder formed by the decomposition of the pyrites can be separated from the unaltered zinc blende simply by sieving.

The crude zinc thus obtained can be refined by simply remelting it and allowing it to stand in the molten state for some time which allows part of the impurities to sink to the bottom while the other part rises to the surface, becomes oxidized, and can be drawn off with the ash. Recently the crude zinc (especially that obtained from blende) has been refined in the reverberatory furnace. Especially pure zinc is obtained if a solution of basic zinc sulphate is first made and then the metal electrolytically precipitated, remelted, and sublimed *in vacuo*.

Numerous inventors have for a number of years been experimenting with a view of directly extracting the zinc from the ores (after previous roasting) and then depositing it electrolytically. Until recently these efforts were without any practical result; this appears to be gradually altering even though the direct electrolytical winning of zinc has not as yet become specially important.

These experiments can be divided into several classes:

In the first group of the processes, the roasted ores are lixiviated with NaOH; the resulting sodium zincate solution is then electrolyzed.

In the second group zinc chloride solutions are electrolyzed; to obtain the ZnCl_2 the ores are either lixiviated with suitable chlorides (or with chlorine), or they are submitted to a chlorinating roasting and then lixiviated; the electrolysis can of course only be carried out after the solution has been freed from impurities. — For processes of this kind Germ. Pat. 155065 may become of importance: it purposes to enrich dilute ZnCl_2 solutions which are unsuitable for direct electrolysis. The process is based on the fact that zinc sulphite, which is insoluble in H_2O , is soluble in hot ZnCl_2 solution, while lead sulphite is insoluble even in concentrated ZnCl_2 solutions. The PbCl_2 which goes into solution converts all the zinc into ZnCl_2 while the Pb itself is precipitated as lead sulphite, as expressed by the equation $\text{PbCl}_2 + \text{ZnSO}_3 \rightarrow \text{PbSO}_3 + \text{ZnCl}_2$. Here the lead as well as the sulphurous acid are precipitated quantitatively by the addition of the theoretical amount of PbCl_2 , so that a very pure solution of zinc chloride is obtained. By repeated alternating or simultaneous additions of PbCl_2 and ZnSO_3 concentrated ZnCl_2 solutions are obtained. The velocity of the reaction is increased by shaking or stirring the hot mixture.

The third group of processes provides for the electrolysis of zinc sulphate solutions, that is, the ores are lixiviated with sulphates or H_2SO_4 . In the newest processes ZnCl_2 is obtained from the ores by means of electrolytically prepared chlorine, and the fused salt is then electrolyzed, when pure Zn separates at the cathode while free chlorine is regenerated at the anode.

In the ASHCROFT-SWINBURNE process the sulphide ores are converted by chlorine into ZnCl_2 , the latter lixiviated, and the lye evaporated over a free fire; the product thus contains oxychloride. The decomposition of the residue is brought about in iron cells lined with fire clay bricks; the cathode is of fused zinc, the anode of carbon. The melting of the electrolyte is carried out like the decomposition by means of the current; a current of about 10 000 amp. and E. M. F. of 3000–4000 volt being employed.

We cannot here enter into details of the extremely numerous patents for the electrolytical winning of zinc; it suffices to say that though here and there Zn is made electrolytically there are still many difficulties to be overcome, above all with regard to the questions as to which materials are most suitable for cathodes and anodes, whether it is advantageous to use a diaphragm, of what the diaphragm should be made, and how it should be constructed, &c. Only two patents of SIEMENS and HALSKE will here be mentioned. Germ. Pat. 151988 protects a process for the direct electrolytical smelting of zinc oxide ores without the employment of a diaphragm and using an insoluble anode and zinc sheets as cathode. Germ. Pat. 162785 prevents the formation

of spongy zinc and other drawbacks in the electrolysis of zinc sulphate solutions, by having a much higher current at the anode than at the cathode. With this end in view either the cathode surface is made correspondingly smaller or the anode is strengthened at different places with bands, ribs, wires, &c., so that these parts are better conductors and therefore receive more current. The process produces a smooth, solid crystalline zinc free from sponge. As the necessary anodes are very small platinum or platinum alloy can be used, which completely prevents any contamination of the electrolyte by the anode during electrolysis.

For melting and distilling zinc the electric furnace has recently been largely employed. A process for the uninterrupted distillation of Zn direct from the ores in the electric radiating furnace — in which the non-volatile constituents are reduced to ash — is protected by Germ. Pat. 148439, 157603 and 162535. Another process for obtaining Zn in the electric furnace is treated of in Germ. Pat. 158545.

By the reduction and distillation of raw zinc the so-called zinc dust (*Poussière*) (that is a mixture of finely divided zinc powder and ZnO) settles at the beginning of the distillation in the receivers which have not yet become warm.

Zinc in the cast state has a S. G. 6.86, rolled 7.20; in the chemically pure state and cast S. G. = 6.91. It is a greyish white or bluish metal, at ordinary temperature hard, brittle and pulverisable, at 100—150° it is ductile, malleable and very dense, above 200° it is again brittle and pulverisable. M. P. 412° (according to latest investigations 417.6°), B. P. 950° (recently the B. P. of Zn has been found to be 730°). It remains unaltered in dry air and in water free from air, but in damp air becomes coated with a thin film of basic carbonate which protects the metal from further action. It readily dissolves in dilute acids — especially when it is not quite pure; with dilute H_2SO_4 and dilute HCl it evolves hydrogen.

It is used for casting objects of art, for the manufacture of vessels which are constantly in contact with water (baths, pipes, spouts, roofs) further, for printing plates, for zinc plating (galvanizing) of iron, for the electrode plates of galvanic batteries, &c. It is also used for the preparation of numerous alloys and compounds. Zinc dust is largely used in chemical industry as a reducing agent.

Zinc alloys. These are given under the alloys of the other components. See articles on "ALUMINIUM ALLOYS", "COPPER ALLOYS", "NICKEL ALLOYS", &c. as well as also "BRONZES" and "BEARING METALS".

Zinc colours.

1. **ZINC WHITE** (Permanent white; snow white; zinc oxide). ZnO . It is prepared by igniting Zn in the air, or directly from the ore by roasting. Also obtained as a secondary product in the formation of silver in PARK'S process (see "SILVER"). According to ELLERSHAUSEN and WESTERN (Germ. Pat. 151022) zinc white can be obtained directly from zinc blende by lixiviating with acid solutions of alkali-sulphates, and precipitating the Zn from the resulting $ZnSO_4$ solutions by NH_3 . — According to the OETTL process a warm Na_2SO_4 solution can be electrolyzed between zinc electrodes, $ZnSO_4$ goes into solution at the anode, while $Zn(OH)_2$ is precipitated at the cathode by the NaOH formed; the hydroxide can be filtered off and converted into the oxide by heating. This process is probably too expensive to allow of its finding commercial application.

Zinc white is a white paint of good body which has the advantage over white lead that it is not turned black by the action of H_2S .

2. **LITHOPONE** (zincolith; GRIFFITH'S white). Mixture of ZnS with BaSO_4 (and ZnO) which is obtained by precipitating zinc sulphate solutions with BaS solution. To prevent it from turning black afterwards it must be precipitated in hot concentrated solutions and less than 1 % of freshly precipitated magnesium hydroxide and ordinary salt added to the precipitate. The precipitate is then washed, dried, crushed, mixed with 3 % of sal ammoniac, and heated. The heated mass is then broken up by being thrown while still hot into cold water, then dried again and ground. Lithopone is manufactured in large quantities as a white paint. It is met with in commerce in varieties: yellow seal with 11—18 % ZnS , blue seal with 22—30 % ZnS , and green seal with 32—42 % ZnS .

Engl. Pat. 1836, 1837, 3768 and 3769, 6521 (1903) treat of the preparation of colours which are practically nothing more than lithopone.

3. **ZINC-BARIUM PAINTS**. Besides the real lithopones there are many similar paints the manufacture of which is protected by the Engl. Pat. 11112, 11113, 13812, 13813, and 17784 (1903). These paints are mixtures of zinc hydroxide and barium carbonate; they contain also barium sulphate. In the paints of the Engl. Pat. 11113 and 13813 the zinc is not present as the hydroxide but as the carbonate.

4. **ZINC GREY**. Finely ground zinc blende is brought as such into commerce, as is also a mixture of ZnO with finely divided charcoal which is obtained as a by-product in the manufacture of zinc white.

Zinc gray finds employment as a silver gray oil paint of good body.

5. **ZINC YELLOW** (zinc chromate; zinc chrome yellow). Obtained by precipitating solutions of zinc salts with alkali chromates; usually basic chromates. Very often it is prepared by boiling zinc white with sodium hydroxide and precipitating the resulting solution with $\text{K}_2\text{Cr}_2\text{O}_7$.

On account of its absolute fastness to light it is much prized as a paint.

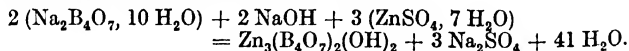
6. **ZINC GREEN**. A mixture of zinc yellow with Parisian blue (see "IRON COLOURS").

Zinc compounds.

1. **AMMONIUM ZINC CHLORIDE** (soldering salt) see "SOLDERING".

2. **ZINC ACETATE**. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$. It is obtained by dissolving zinc white (see "ZINC COLOURS") in dilute acetic acid, precipitating foreign metals by throwing in metallic zinc, filtering after standing for some days, and evaporating to crystallization. It forms white greasy crystals with a lustre like mother of pearl, efflorescing in the air and readily soluble in H_2O , sparingly soluble in alcohol. If the salt be allowed to crystallize at the normal temperature it contains 3 mol. H_2O , in the other hand when it crystallizes while hot it only contains 1 mol. H_2O .

3. **ZINC BORATE**. The basic salt, which of late years has been used for the preparation of zinc powder for wounds, has according to HOLTZMANN the formula $\text{Zn}_3(\text{B}_4\text{O}_7)_2(\text{OH})_2$. It can be obtained by adding a borax solution which has been treated with NaOH to a solution of zinc sulphate, in the proportions expressed by the following equation



4. **ZINC CHLORIDE**. ZnCl_2 . Obtained by dissolving zinc scraps, zinc blende and ZnO (roasted zinc ores) in HCl . Zinc chloride solution, free from iron, can be obtained (commercially) according to Germ. Pat. 136521 by treating zinc compounds with ferrous chloride — air being at the same time passed through — the iron is said to be completely precipitated and the zinc to pass into solution as almost pure ZnCl_2 . According to Germ. Pat. 158087 to obtain ZnCl_2 from waste or ores the latter are heated not quite to the temperature

of sublimation of ZnCl_2 (550°) and HCl gas passed in either alone or mixed with air; the ZnCl_2 is then extracted, by systematic lixiviation, from the waste and ores thus treated. For the process of K. J. BAYER for simultaneous production of alkali chlorate and ZnCl_2 , see "POTASSIUM CHLORATE" (No. 6 in the article "POTASSIUM COMPOUNDS").

Anhydrous ZnCl_2 is obtained by heating ZnSO_4 with NaCl when ZnCl_2 sublimes. In the anhydrous state it forms a white, transparent, very hygroscopic mass, extremely soluble in H_2O . From the syrupy solution, colourless, deliquescent crystals with 1 mol. H_2O can be obtained. It is poisonous, it carbonizes wood, oxidizes alcohol to ether, and acts generally on organic substances in a way similar to concentrated H_2SO_4 . It is used for impregnating wood, for preserving animal stuffs, for the manufacture of parchment paper, of ether, and dyestuffs. It is employed in the refining of oil, as a disinfectant, as a caustic, and in dyeing.

TEST. It is brought into commerce in the solid form and in solution. It is usually only tested for the presence of zinc oxychloride which can be readily detected since the pure ZnCl_2 gives a clear solution in water. The solution is then tested for free acids; if these are present ultramarine paper becomes decolourized.

5. ZINC CHROMATE, see ZINC YELLOW under "ZINC COLOURS".

6. ZINC HYDROSULPHITE. This preparation which is intended to find employment in vat dyeing, partly as such and partly with the substitution of Zn by another metal, is obtained in the form of a solid mass sparingly soluble in H_2O (Germ. Pat. 130403 and 137497). Sulphites are treated with zinc dust in the presence of H_2O and dilute acid at a moderate heat.

7. ZINC CARBONATE. ZnCO_3 . It occurs in nature as zinc spar or calamine, and can be precipitated as a white salt from solutions of zinc salts by KHCO_3 or excess of CO_2 ; neutral alkali carbonates precipitate basic carbonates of varying composition.

8. ZINC OXALATE. ZnC_2O_4 . Obtained by precipitating solutions of zinc salts with oxalic acid.

9. ZINC OXIDES.

a) Zinc oxide. ZnO . Preparation, see "ZINC WHITE" and "ZINC COLOURS".

b) Zinc hydroxide Zn(OH)_2 . Obtained in white amorphous flakes by precipitating solutions of zinc salts with alkalis.

c) Zinc peroxide. ZnO_2 . This compound has been prepared recently (according to Amer. Pat. 740832) by allowing BaO_2 suspended in H_2O to act on the zinc salt of an acid which forms an insoluble Ba salt. According to Germ. Pat. 151129 it can be prepared electrolytically in a cell provided with a diaphragm. The anode chamber contains aqueous ZnCl_2 solution, the cathode chamber a mixture of hydrogen peroxide and ZnCl_2 solution. When the current passes (2.5—3 volt) zinc peroxide separates at the platinum cathode and readily falls off and into the electrolyte. It is then collected, washed, and dried at a moderate temperature.

Under the name zinc perhydrol a white powder consisting of equal parts of ZnO_2 and ZnO is brought into commerce; it is recommended as a powder for dressing wounds.

It is a white velvety powder; the commercial article contains 50—60 % of pure ZnO_2 . Amongst other things it is used in medicine as it has proved itself to be very beneficial in the treatment of wounds and perhaps is even destined to replace ZnO .

10. ZINC SMOKE, see article on "CADMIUM".

11. ZINC DUST, see article on "ZINC".

12. ZINC PERHYDROL, see No. 9c) "ZINC PEROXIDE".

13. ZINC SULPHATE (white vitriol). ZnSO_4 . It is prepared by dissolving zinc scraps in H_2SO_4 , or by roasting zinc blende and then lixiviating with hot

dilute H_2SO_4 . Cu is removed from the solution by introducing zinc, while the FeSO_4 is removed by heating for a long time in the air; the lye is then filtered and evaporated to crystallization. The crystallized salt ($\approx 7 \text{ H}_2\text{O}$) is melted, stirred until it is cold, and hammered into moulds resembling sugar loaves. It can be further purified by recrystallization. According to Germ. Pat. 135056 for the preparation of a ZnSO_4 solution from mixed sulphide ores, the latter are worked in the known way and converted into a sulphate mixture, and then roasted with $\text{Ca}(\text{OH})_2$ and NaNO_3 in a muffle furnace in order to drive off completely the impurities or to convert them into insoluble compounds; after the roasting is finished the ZnSO_4 is lixiviated out — which process is assisted by the Na_2SO_4 derived from the NaNO_3 . Finally the newer processes (Germ. Pat. 120822 and 135182) may be mentioned; these treat of the preparation of ZnSO_4 and are described under copper sulphate in the article "COPPER COMPOUNDS".

Zinc vitriol forms colourless, superficially efflorescent crystals, which lose 6 molecules of H_2O at 100° and the seventh by gently heating. 100 parts H_2O dissolve at 10° , 138 parts, at 20° , 161 parts, at 50° , 264 parts, at 100° , 654 parts crystallized zinc vitriol. It is used for preserving wood and hides, for the preparation of varnish, of oxygen, fuming H_2SO_4 , for disinfecting, as a flame proof agent, for the preparation of other zinc compounds, as a mordant in calico printing, and as a medicament.

14. ZINC SULPHIDE. ZnS . Occurs in nature as zinc blende, and is also artificially obtained by precipitating solutions of zinc salts with alkali sulphides. According to Germ. Pat. 132916 zinc sulphide and ammonium cyanide can be obtained simultaneously from zinc ores of little value by dissolving the ores in dilute NH_3 and then allowing the gases from coke furnaces, impure gas (or other gases containing H_2S and CN compounds) to act on this ammoniacal solution; the gases are passed in until the $\text{Zn}(\text{CN})_2$, which is at first formed together with ZnS , has also been converted into ZnS ; all the CN is then present as NH_4CN . According to Germ. Pat. 137801 copper slags containing Zn and Ba are finely ground and then treated with just enough HCl to bring the Ba, Ca, and Fe into solution as chlorides, while the ZnO is converted into insoluble ZnS . According to Germ. Pat. 149557 pure ZnS may be obtained by lixiviating the raw materials with a slightly acid solution of iron sulphate, and precipitating the resulting ZnSO_4 solution with H_2S ; the mother liquor can be used for lixiviating fresh amounts of raw material.

A product is obtained according to Germ. Pat. 167172, Suppl. Pat. 167498, 171872, 179022 by precipitating barium zincate with BaS in aqueous solution in presence of H, or by heating alkali zincates with alkali sulphides, e.g. granulated Zn may be boiled with NaOH (iron filings being added to further the liberation of H) and then the solution precipitated with an alkali sulphide.

ZnS is white, insoluble in water and acetic acid, readily soluble in dilute mineral acids (see LITHOPONE under "ZINC COLOUR").

Zinc dust see "Zinc".

Zinc perhydrol see ZINC PEROXIDE in article on "ZINC COMPOUNDS", No. 9c.

Zinc plating. Iron is practically the only metal which is zinc plated (galvanized); the object is to render it rust proof; see "RUST PROTECTIVES".

When iron sheets are to be zinc plated, they are carefully cleaned (in a mixture of diluted H_2SO_4 and HCl), then rinsed, dried, glazed, rolled cold, again cleaned and finally rinsed. They are then treated with a soldering liquid consisting of 50 parts of water, 50 parts of hydrochloric acid, 3 parts of zinc chloride and 1.5 parts of ammonium chloride. When this liquid has dried on the sheets they are taken up with tongs and dipped for a few seconds into

molten zinc; the zinc must be covered with sal ammoniac to prevent oxidation. On leaving the zinc bath, the plates may be thrown straight into cold water though this has the effect of making them hard and brittle; it is better to let them cool gradually in hot water, or preferably in heated palm oil.

When wire is to be zinc plated it is wound off one drum, passed through various vessels cleaning, rinsing, and zinc-vats, and on to a second drum.

A new method of galvanizing iron has been invented by COWPER-COLES; the essential difference is that zinc is used in the solid form as zinc dust. The article is cleaned as usual mechanically by sand blasts or by cauterizing and is then packed with the zinc dust in an iron cylinder. The cylinder is then heated for a few hours to 250—300° C and allowed to cool. The zinc layer is even and uniform, the thickness depending on the length of time it is heated. Nuts, bolts, &c. with finished surfaces need not be freed from adhering oil; they can be galvanized without preparation, as oily matter appears to be favourable to the process. The cylinder is lined with graphite paint to prevent the Zn from depositing and it must be air-tight so that the Zn does not burn to oxide, which of course, would be detrimental to the process. Zinc dust is obtained in any quantity by distillation of the commercial ores. This new process seems to be simple in working, and as the requisite temperatures are low the mechanical properties of the articles remain practically unaltered; the greatest advantage over the hot method is that the same surface to be covered requires less zinc as it is more uniformly distributed. See also Germ. Pat. 165977 and Suppl. Pat. 166671 and 168202 dealing with the addition of Al, Bi and Sn to the bath.

Zinc plating by electricity has had to contend with many difficulties, all of which are apparently not yet overcome. Several establishments work as follows: The iron articles to be zinc plated are not cauterized, as in that case the Zn precipitated electrolytically does not adhere well; instead they are cleaned by sand blasts. The zinc bath is a solution of 11.3 kg crystallized zinc sulphate and 1.5 kg ferrous sulphate in 45 kg H₂O. The process is said to result in a bright zinc covering which adheres very firmly.

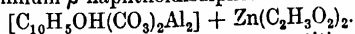
According to O. GABRAN'S investigations (Chem.-Ztg. 1903, Rep. 308) the most suitable solution with which to zinc-plate iron, is 1200 g zinc sulphate and 60 g sulphuric acid of 24° Bé to 6 litres H₂O; the current used in vats of larger dimensions was 6 amp. at 8—10 volts.

French Pat. 328282 protects an apparatus for electrolytical zinc plating of iron sheets. Germ. Pat. 151336 adds pyridine to the electrolyte of hydrochloric acid and zinc chloride solution; a very dense firm plating is said to be the result.

— According to Germ. Pat. 154492 a dense and durable zinc plating on iron is obtained by adding gum Arabic to the bath. The bath itself, recommended by this patent contains 5 kg of a 50 % ZnCl₂ solution, treated with a solution of 1.5 kg Na₂CO₃ in 10 litres H₂O; besides this, a hot solution of 3 kg NH₄Cl in 20 litres H₂O with 6 kg gum Arabic is made. The two solutions are stirred together, heated for a short time and then made up to 100 litres with H₂O.

Zincalium. An alloy of Al with small amounts Mg and Zn. S. G. 2.65 to 2.75. Harder and cheaper than Al, easily workable, is however not so resistant towards chemical action, and is not such a good conductor of electricity as the unalloyed metal.

Zinol = Aluminium- β -naphtholdisulphonate zinc acetate.



It is obtained by combining molecular quantities of alumnol (q. v.) and zinc acetate.

Odourless white powder, very soluble in H₂O. It is used medicinally on account of its astringent and disinfecting properties.

Zirconium and Zirconium compounds. ZIRCONIUM Zr (A. W. = 90.6), is a rare metal of no industrial value. Its most important natural compound is zircon, ZrSiO_4 , which is used for the preparation of zirconium dioxide ZrO_2 . ZrSiO_4 is treated with H_2SO_4 and the zirconium hydroxide Zr(OH)_4 separated with NH_3 . ZrO_2 is obtained as a hard, infusible white powder by heating Zr(OH)_4 . In the oxy-hydrogen flame it emits a brilliant white light. It is used in the manufacture of incandescent light mantles.

Zirconium lamps. Formerly a zirconium lamp was an arrangement in which a small rod of zirconium oxide was made white hot in an oxy-hydrogen flame.

The name is now given to an electric lamp similar in principle to an osmium lamp (q. v.), the incandescent thread being of zirconium instead of osmium. According to WEDDING, zirconium oxide and magnesia are subjected to the action of hydrogen at a high temperature. The hydrogen combines with the zirconium to form zirconium hydride, which is made into a plastic substance with cellulose and drawn into threads. 100 000 threads can be made from 1 kg zircon, and the price of each lamp is said to be 1/6d. 2 watts per candle power are required and the voltage must not exceed 37. Its life is 700 to 1000 hours without any deposit forming on the inside of the glass.

Zirconium lamps have not yet passed out of the experimental stage, and it remains to be seen whether it is a reliable source of light. One thing is certain, the light emitted is very intense and pure white.

Ziskon see "ALUMINIUM ALLOYS".

Supplement.

Ice. S. G. of pure ice at $0^{\circ} = 0.9167$. Latent-heat of fusion 80.025 calories.

Ice is prepared artificially either by means of ice machies or by the use of freezing mixtures.

Freezing mixtures are salts or mixtures of salts which cause a lowering of temperature when dissolved. The lowering of temperature increases with the heat of solution, solubility and concentration of the solution, and is greater the lower the freezing point of the solution, since the freezing point marks the limit of cooling. The mixtures, in order to give satisfactory results, must be used in relatively large amounts, and be cooled as far as possible before use. The solids used should be finely powdered.

A. MIXTURES WITH WATER.

Mixture		Cooling	
		From	To
5 parts	ammonium chloride	+ 10°	— 17°
5 "	potassium nitrate		
16 "	water		
5 "	ammonium chloride	+ 10°	— 20°
5 "	potassium nitrate		
8 "	sodium sulphate (cryst.)		
16 "	water	+ 10°	— 20°
1 "	ammonium nitrate		
1 "	water		
1 "	ammonium nitrate	+ 10°	— 25°
1 "	sodium carbonate (cryst.)		
1 "	water		
3 "	potassium sulphocyanide	+ 10°	— 25°
2 "	water		
5 "	calcium chloride (cryst.)	+ 10°	— 15°
3 "	water		

B. MIXTURES WITH DILUTE ACIDS.

3 parts	sodium sulphate (cryst.)	+ 10°	— 20°
2 "	dil. nitric acid (2 acid, 1 water)		
6 "	sodium sulphate (cryst.)	+ 10°	— 25°
4 "	ammonium chloride		
2 "	potassium nitrate		
4 "	dil. nitric acid	+ 10°	— 28°
6 "	sodium sulphate (cryst.)		
5 "	ammonium nitrate		
5 "	dil. nitric acid	+ 10°	— 20°
6 "	sodium phosphate		
4 "	dil. nitric acid	+ 10°	— 18°
5 "	sodium sulphate (cryst.)		
4 "	dil. sulphuric acid (1 acid, 1 water)	+ 10°	— 22°
8 "	sodium sulphate (cryst.)		
5 "	conc. hydrochloric acid		

C. MIXTURES WITH SNOW OR POWDERED ICE

		Mixture	Cooling	
1 part	sodium chloride	}	0°	—20°
2 "	snow			
1 "	ammonium chloride	}	0°	—30°
2 "	sodium chloride			
5 "	snow	}	0°	—35°
1 "	ammonium chloride			
2 "	sodium chloride	}	0°	—40°
1 "	potassium nitrate			
5 "	snow	}	0°	—50°
5 "	sodium chloride			
5 "	ammonium nitrate	}	0°	—50°
12 "	snow			
5 "	calcium chloride (cryst.)	}	0°	—35°
4 "	snow			
3 "	calcium chloride (cryst.)	}	0°	—35°
2 "	snow			
5 "	potassium hydroxide (cryst.)	}	0°	—50°
3 "	snow			
1 "	sulphuric acid (diluted with 20% of its weight of water)	}	—7°	—50°
3 "	snow			
1 "	conc. hydrochloric acid S. G. 1.18	}	0°	—37.5°
1 "	snow			
1 "	nitric acid	}	0°	—56°
2 "	snow			

Lighting. The relative costs of different kinds of lighting are given in the following tables taken from the Journ. f. Gasbeleucht. 1904, 141.

Kind of Light	Light in C. P. ¹⁾	Hourly consumption litres	Consumption per C. P. litres	Cost per unit in shillings	Cost per hour in shillings	Cost of production per C. P. in shillings
Coal gas:—						
Fish-tail burner . .	16	160	10.00	0.16	0.0256	0.016
Argand burner . .	32	250	7.80	0.16	0.04	0.0125
Incandescent burner	72	120	1.70	0.16	0.0192	0.0027
Millenium light . .	1400	1200	0.85	0.16	0.227	0.0017
Acetylene:—						
Fish-tail burner . .	50	30	0.60	1.25	0.0375	0.0075
Incandescent light .	60	15	0.25	1.25	0.0188	0.0031
Petroleum:—						
		kg	g			
Circular burner . .	30	0.08	2.70	0.25	0.02	0.0067
Kiteon light . . .	900	0.33	0.37	0.25	0.0825	0.0092
Alcoholincandescent light	50	0.10	2.00	0.40	0.04	0.008
Electric light:—						
		watt-hours	watts			
Arc light	500	375	0.75	0.6	0.225	0.0045
Bremer light . . .	1000	500	0.50	0.6	0.300	0.0030
Liliput arc light .	130	160	1.23	0.6	0.096	0.0074
Nernst lamp . . .	180	218	1.21	0.6	0.1308	0.0073
Glow lamp	16	55	3.44	0.6	0.0330	0.0206

¹⁾ C. P. = Candle Power.

It should be noted that the cost of acetylene as given in the above table is unusually low (1.25 shillings), as the consumer generally pays 1.9 shillings per cubic metre.

The heat evolved in the different systems of lighting is given in the following table compiled by Prof. W. WEDDING.

Kind of Light	Light in C. P.	Hourly con- sumption in litres	Heat evolved per hour in heat units	
			Total	Per C. P.
Gas lighting:—				
Bray burner	30	400	2000	66.7
Argand burner	20	200	1000	50
Regenerative burner	111	408	2042	18.4
Incandescent light	50	100	500	10
Lucas light	500	500—600	2500 3000	5—6
Alcohol incandescent light	30	0.057	336	11.2
Petroleum light	30	0.108	862	28.7
Acetylene light	60	36	328	5.5
Electric lighting:—				
Carbon filament light	16	Watts 48	41.5	2.59
Nernst light	25	38	32.8	1.3
Arc light	600	258	222	0.37

The following more recently compiled table by Prof. W. WEDDING is taken from the Journ. f. Gasbeleuchtung 1905.

Kind of Light	Light		Hourly consumption	Heat evolved per hour in calories	Calories per 1 C. P.	Cost of burning for one hour in shillings		CO ₂ evolved per hour in litres
	Horizontal C. P.	Spherical C. P.				Total	Per C. P.	
Petroleum light	14.8	13.2	43.6 g	480	36.4	0.0109	0.00083	70.1
Alcohol incandescent light	65.3	42.9	129 g	698	16.3	0.0378	0.00088	119
Upright incandescent light	73.8	52.3	112.3 l	573	11.0	0.0139	0.00027	59.1
Compressed gas	303	214	272 l	1387	6.48	0.0386	0.00018	143
Lucas light	581	411	630 l	3210	7.82	0.0778	0.00019	332
Millenium light	1500	1060	1200 l	6120	5.77	0.1480	0.00014	631
Carbon filament lamp	43.8	34.6	104 Watts	89.8	2.6	0.0416	0.00120	—
	18.3	12.8	59.1 "	51.0	3.99	0.0236	0.00184	—
Onium light	42.3	31.4	48.7 "	42.1	1.34	0.0195	0.00062	—
Nernst light	184.5	113	213 "	184	1.63	0.0852	0.00075	—
Arc light	—	400	440 "	380	0.95	0.1760	0.00044	10.7

The following table compiled from the researches of H. LUX show:—
a the consumption per hour, b the light energy in percentages of the total energy consumed, c the horizontal and d the spherical illumination.

	a	b	c	d
		%	C. P.	C. P.
Hefner lamp	9.25 g	0.103	1.0	0.825
Petroleum lamp, 14"	39.73 g	0.25	14.2	12.0
Acetylene flame	7.2 l	0.65	7.7	6.04
Incandescent gas, vertical	121.5 l	0.46	107.0	89.6
" " inverted	96.8 l	0.51	107.0	82.3
Lucas light	630.0 l	0.5 (approx.)	581.0	411.0
Millenium light	1200.0 l	0.6 "	1500.0	1060.0
Electric carbon filament lamp	98.23 Watts	2.07	31.5	24.5
Nernst lamp	181.4 "	4.21	120.1	94.9
Tantalum lamp	44.0 "	4.87	34.6	26.7
Osram lamp	38.3 "	5.36	36.3	27.4
Direct current arc lamp	435.0 "	5.60	190.0	524.0
Arc lamp for yellow light	350.0 "	13.20	907.0	1145.0
" " " white	348.0 "	6.66	602.0	760.0
Alternating current arc lamp	181.0 "	1.90	109.0	89.0
Uviol-Mercury lamp	198.6 "	2.24	437.0	344.0
Quartz lamp	691.0 "	6.00	3400.0	2960.0

The following table dealing with the cost of different kinds of lighting was compiled by H. DÖRR and is valuable on account of its completeness. The figures are however, not valid for all districts. The costs of fuel or electrical energy have been taken from average values.

It should be observed that certain forms of lighting (e.g. Washington light, Flame arc lamp &c.) are only suitable for large installations.

kind of light	Cost of material or energy in shillings	Cost per normal Candle-power- hour in shillings
Washington light (Petroleum incandescent under pressure)	1000 g = 0.22	0.00010
Flame arc lamp	1000 Watt-hours = 0.50	0.00016
Mercury vapour lamp	1000 " = 0.50	0.00025
Incandescent gas	1000 l = 0.16	0.00025
Petroleum (incandescent) light	1000 g = 0.22	0.00030
Arc light (direct)	1000 Watt-hours = 0.50	0.00040
Metallic filament lamps (osram, zirconium, tungsten, &c.)	1000 " = 0.50	0.00050
Petroleum	1000 g = 0.22	0.00070
Osmium lamp	1000 Watt-hours = 0.50	0.00075
Tantalum lamp	1000 " = 0.50	0.00080
Alcohol incandescent	1000 g = 0.40	0.00080
Arc lamp (alternating)	1000 Watt-hours = 0.50	0.00080
Nernst lamp	1000 " = 0.50	0.00085
Small arc lamp	1000 " = 0.50	0.00090
Acetylene light	1000 l = 1.20	0.00120
Carbon filament lamp	1000 Watt-hours = 0.50	0.00160
Gas (circular burner)	1000 l = 0.16	0.00160
Gas (Fish-tail burner)	1000 l = 0.16	0.00250
Stearin candle	1000 g = 1.50	0.01100

See also articles MOLYBDENUM LAMPS, NERNST LAMPS, OSMIUM LAMPS, MERCURY VAPOUR LAMPS, TANTALUM LAMPS, TUNGSTEN LAMPS and ZIRCONIUM LAMPS.

APPENDIX.

I. Conversion of litres into English Gallons.

Litres	0	1	2	3	4	5	6	7	8	9	
0	0.00	0.22	0.44	0.66	0.88	1.10	1.32	1.54	1.76	1.98	
10	2.20	2.42	2.64	2.86	3.08	3.30	3.52	3.74	3.96	4.18	
20	4.40	4.62	4.84	5.06	5.28	5.50	5.72	5.94	6.16	6.38	
30	6.60	6.82	7.04	7.26	7.48	7.70	7.92	8.14	8.36	8.58	
40	8.80	9.02	9.24	9.46	9.68	9.90	10.1	10.3	10.6	10.8	
50	11.0	11.2	11.4	11.7	11.9	12.1	12.3	12.5	12.8	13.0	
60	13.2	13.4	13.6	13.9	14.0	14.3	14.5	14.7	15.0	15.2	
70	15.4	15.6	15.8	16.0	16.3	16.5	16.7	17.0	17.2	17.4	
80	17.6	17.8	18.0	18.3	18.5	18.7	18.9	19.1	19.4	19.6	
90	19.8	20.0	20.2	20.5	20.7	20.9	21.1	21.3	21.6	21.8	
100 = 22.0	500 = 110.0			900 = 198.0		1300 = 286.0		1700 = 374.0		3000 = 660.0	
200 = 44.0	600 = 132.0			1000 = 220.0		1400 = 308.0		1800 = 396.0		4000 = 880.0	
300 = 66.0	700 = 154.0			1100 = 242.0		1500 = 330.0		1900 = 418.0		5000 = 110.0	
400 = 88.0	800 = 176.0			1200 = 264.0		1600 = 352.0		2000 = 440.0		6000 = 132.0	

II. Conversion of English Gallons into litres.

Galls.	0	1	2	3	4	5	6	7	8	9	
0	0.0	4.5	9.1	13.6	18.2	22.7	27.3	31.8	36.4	40.9	
10	45.4	50.0	54.5	59.1	63.6	68.2	72.7	77.2	81.8	86.3	
20	90.9	95.4	100.0	104.5	109.1	113.6	118.2	122.7	127.2	131.8	
30	136.3	140.9	145.4	149.9	154.5	159.0	163.6	168.1	172.7	177.2	
40	181.8	186.3	190.8	195.4	199.9	204.5	209.0	213.6	218.1	222.6	
50	227.2	231.7	236.3	240.8	245.4	249.9	254.5	259.0	263.5	268.1	
60	272.6	277.2	281.7	286.3	290.8	295.4	299.9	304.4	308.9	313.5	
70	318.1	322.6	327.2	331.7	336.3	340.8	345.3	349.9	354.5	359.0	
80	363.5	368.1	372.6	377.1	381.7	386.2	390.8	395.3	399.9	404.4	
90	409.0	413.5	418.0	422.6	427.1	431.7	436.2	440.8	445.3	449.9	
100 = 454.4	300 = 1363.2			500 = 2272.0		700 = 3180.8		900 = 4089.6		1500 = 6816.0	
200 = 908.8	400 = 1817.6			600 = 2726.4		800 = 3635.2		1000 = 4544.0		2000 = 9088.0	

III. Conversion of litres into American Gallons.

Litres	0	1	2	3	4	5	6	7	8	9
0	0.00	0.26	0.53	0.79	1.06	1.32	1.58	1.85	2.11	2.38
10	2.64	2.90	3.17	3.43	3.70	3.96	4.22	4.49	4.75	5.02
20	5.28	5.54	5.81	6.07	6.34	6.60	6.86	7.13	7.39	7.66
30	7.92	8.18	8.45	8.71	8.97	9.24	9.50	9.77	10.03	10.30
40	10.56	10.82	11.09	11.35	11.62	11.88	12.14	12.41	12.67	12.94
50	13.20	13.46	13.73	13.99	14.26	14.52	14.78	15.05	15.31	15.58
60	15.84	16.10	16.37	16.63	16.90	17.16	17.42	17.69	17.95	18.22
70	18.48	18.74	19.01	19.27	19.54	19.80	20.06	20.32	20.59	20.86
80	21.12	21.38	21.65	21.91	22.18	22.44	22.70	22.97	23.23	23.50
90	23.76	24.02	24.29	24.55	24.82	25.08	25.34	25.61	25.87	26.14
100 = 26.4	500 = 132.0			900 = 337.6		1300 = 443.2		1700 = 448.8		3000 = 792.0
200 = 52.8	600 = 158.4			1000 = 264.0		1400 = 369.6		1800 = 475.2		4000 = 1056.0
300 = 79.2	700 = 184.8			1100 = 290.4		1500 = 396.0		1900 = 501.6		5000 = 1320.0
400 = 105.6	800 = 211.2			1200 = 316.8		1600 = 422.4		2000 = 528.0		6000 = 1584.0

IV. Conversion of American Gallons into litres.

Galls.	0	1	2	3	4	5	6	7	8	9
0	0.0	3.8	7.6	11.4	15.2	18.9	22.8	26.5	30.2	34.1
10	38.0	41.6	45.5	49.3	53.0	56.9	60.6	64.5	68.2	72.0
20	75.8	79.5	83.4	87.2	91.0	94.7	98.5	102.2	106.1	110.0
30	113.8	117.5	121.2	125	129	133	136	140	144	148
40	152	155	159	163	167	171	174	178	182	186
50	190	193	197	201	205	209	213	217	220	224
60	228	231	235	239	242	246	250	254	258	262
70	266	269	273	277	280	284	288	292	296	300
80	303	307	311	315	319	322	326	330	334	337
90	341	345	349	353	357	360	364	368	372	375
100 = 378	300 = 1138			500 = 1900		700 = 2660		900 = 3410		1500 = 5690
200 = 758	400 = 1520			600 = 2280		800 = 3030		1000 = 3780		2000 = 7580

Foreign Weights and Measures.

	Length	m	Volume	l.	Weight	kg.
Australia...	1 Yard (3 feet)	0.91	1 Quarter (8 bushels)	290.59	1 Cwt. (4 quarters)	50.782
Austria...	metric	1.00	metric	1.00	metric	1.000
Belgium...	"	1.00	"	1.00	"	1.000
Brazil...	"	1.00	"	1.00	"	1.000
China...	1 Yin=12 Tsch (feet)=10 Tsun	3.58	1 Sai (grain)	122.43	1 Picul (100 Catrys)	60.480
Denmark...	metric	1.00	metric	1.00	1 Cwt. (100 pounds)	50.000
East Indies.	1 Guz (Calcutta)	0.91	1 Gallon (4 Quarts)	4.54	1 Bazar Maund (40 Seers)	37.320
France...	1 Cubit	0.46	metric	1.00	metric	1.000
Germany...	1 Meter (100 cm)	1.00	1 Hektoliter (100 liters)	100.00	1 Ton (1000 kg) (1 kg)	1.000
Great Britain	1 Yard (3 feet)	0.91	1 Quarter (8 bushels)	290.78	1 Cwt. (4 Quarters)	50.508
Greece...	1 Piki (10 Palamai)	1.00	1 Gallon (4 Quarts)	4.54		
Holland...	metric	1.00	1 Kollon (100 liters)	100.00	1 Mina (1500 Dr.)	1.500
Japan...	1 Schaku Kane (10 Sun)	0.30	1 Mud (Sack) (100 Koppen)	100.00	metric	1.000
Italy...	metric	1.00	1 Koku (100 Sjo)	175.00	"	1.000
Mexico...	"	1.00	metric	1.00	"	1.000
Norway...	"	1.00	"	1.00	"	1.000
Portugal...	"	1.00	"	1.00	"	1.000
Romania...	"	1.00	"	1.00	"	1.000
Russia...	1 Arshin (16 Vershoks)	0.71	1 Vedro (10 Kruschka)	12.30	1 Berkowets (10 Pud)	163.800
Sweden...	metric	1.00	1 Chetvert	210.00	metric	1.000
Switzerland	"	1.00	metric	1.00	"	1.000
Spain...	"	1.00	"	1.00	"	1.000
Turkey...	"	1.00	1 Kile	100.00	1 Cantar (100 Okes)	50.000
United States	1 Yard (3 feet)	0.91	1 Bushel (8 Quarts)	35.24	English weights	

Table for the calculation of analyses.

Weighed as	Required	Factor	Weighed as	Required	Factor
Aluminium			Arsenic		
Al ₂ O ₃	Al ₂	0.53033	As ₂ O ₃	As ₂ O ₃	0.80439
Al ₄ (P ₂ O ₄) ₂	Al ₂ O ₃	0.41850	2 As ₂ O ₃	As ₂ O ₃	0.99929
Ammonium			As ₂ O ₅	As ₂ O ₅	0.93429
NH ₄ Cl	NH ₃	0.31891	As ₂ S ₃	As ₂ S ₃	1.26046
	NH ₄ .OH	0.33775			
2 NH ₄ Cl	(NH ₄) ₂ .O	0.65551	2(MgNH ₄ As	As ₃	0.39380
(NH ₄) ₂ PtCl ₆	2 NH ₃	0.48720	O ₄).H ₂ O	As ₂ O ₃	0.51983
	2 NH ₄ .OH	0.07695		2 As ₂ O ₃	0.64585
	2 NH ₄	0.081504		As ₂ O ₅	0.60384
	2 NH ₄ .OH	0.15818		As ₂ S ₃	0.64631
	(NH ₄) ₂ .O	0.11757		As ₂ S ₅	0.81465
	N ₂	0.063292	Mg ₂ AsO ₇	As ₂	0.48275
	2 NH ₄ .Cl	0.24131		As ₂ O ₃	0.63724
Pt	2 NH ₃	0.17525		2 As ₂ O ₃	0.79172
	2 NH ₄	0.18563		As ₂ O ₅	0.74022
	2 NH ₄ .OH	0.36026		As ₂ S ₃	0.79228
	(NH ₄) ₂ .O	0.26776		As ₂ S ₅	0.99864
	N ₂	0.14415	3 BaSO ₄	As ₂	0.21417
	2 NH ₄ .Cl	0.54959		As ₂ O ₃	0.28271
(NH ₄) ₂ SO ₄	2 NH ₃	0.25820		2 As ₂ O ₃	0.35124
	2 NH ₄	0.27348		As ₂ S ₃	0.35150
	2 NH ₄ .OH	0.53077		As ₂ S ₅	0.44305
(NH ₄) ₂ .O	2 NH ₄ .Cl	0.39449		2 As ₂ S ₄	0.58038
		0.80971			
Antimony			Barium		
Sb ₂ O ₃	Sb ₂	0.83334	BaSO ₄	Ba	0.58853
	Sb ₂ O ₅	1.11112		BaO	0.65705
	2 SbO ₂	1.16668	BaCO ₃	Ba	0.69605
	Sb ₂ S ₃	1.38993		BaO	0.77709
Sb ₂ O ₅	Sb ₂	0.75000	BaCrO ₄	Ba	0.54201
	Sb ₂ S ₃	1.05055		BaO	0.60512
	2 SbO ₂	1.05000	BaSiF ₆	Ba	0.49107
	Sb ₂ O ₃	0.90000		BaO	0.54824
	Sb ₂ S ₅	1.25093		BaF ₂	0.62687
Sb ₂ S ₃	Sb ₂	0.71390	BaCl ₂	Ba	0.65963
	Sb ₂ O ₃	0.85668		BaO	0.73643
	Sb ₂ O ₅	0.95188	Ba(NO ₃) ₂	Ba	0.52547
Sb ₂ S ₅	Sb ₂	0.59956		BaO	0.58665
	Sb ₂ O ₃	0.71947		Ba	0.89772
	2 SbO ₂	0.83938	Bismuth		
	Sb ₂ O ₅	0.79941	Bi ₂ O ₃	2 Bi	0.89679
	Sb ₂ S ₃	0.83983	Bi ₂ S ₃	2 Bi	0.81259
Arsenic				Bi ₂ O ₃	0.90611
As ₂ O ₃	As ₂	0.75757	BiOCl	Bi	0.80208
	2 AsO ₃	1.24242	2 BiOCl	Bi ₂ O ₃	0.89440
	As ₂ O ₅	1.16161		Bi ₂ S ₃	0.98707
	As ₂ S ₃	1.24331	Bromine		
	As ₂ S ₅	1.56715	AgBr	Br	0.42557
As ₂ O ₅	As ₂	0.65217		HBr	0.43095
	As ₂ O ₃	0.86087		BrO ₃	0.68104
	2 AsO ₃	1.06957	2 AgBr	Br ₂ O ₃	0.63848
	As ₂ S ₃	1.07034	Cadmium		
	As ₂ S ₅	1.34912	CdO	Cd	0.87500
As ₂ S ₃	As ₂	0.60931	CdS	Cd	0.77746
				CdO	0.88853

Weighed as	Required	Factor	Weighed as	Required	Factor
Calcium			Fluorine		
CaO	Ca	0.71428		6 HF	0.42909
	CaCl ₂	1.98034		H ₂ SiF ₆	0.51614
CaSO ₄	Ca	0.29399		SiF ₄	0.50893
	CaO	0.41159		SiF ₄	0.37312
	CaCl ₂	0.81508		3 KF	0.62687
CaCO ₃	Ca	0.40000	K ₂ SiF ₆	6 F	0.51654
	CaO	0.56000		6 HF	0.54400
	CaCl ₂	1.10900		H ₂ SiF ₆	0.65436
CO ₂	CaCO ₃	2.27274		SiF ₄	0.64522
Carbon				SiF ₄	0.47304
CO ₂	C	0.27273		2 KF	0.52696
CaCO ₃	CO ₂	0.44000	Hydrogen		
BaCO ₃	CO ₂	0.22289	H ₂ O	H ₂	0.11210
Chlorine			Iodine		
AgCl	Cl	0.24725	I ₂ O ₅	I ₂	0.76026
	HCl	0.25428		2 HI	0.7663
	ClO ₃	0.58202		2 IO ₃	0.04795
	ClO ₄	0.69360	AgI	I	0.54029
	NaCl	0.40801		HI	0.54459
	KCl	0.52029		IO ₃	0.7449
	NaClO ₃	0.74278		IO ₄	0.81289
	KClO ₃	0.85507	2 AgI	I ₂ O ₅	0.71067
	Cl ₂ O ₅	0.52622		I ₂ O ₇	0.77883
2 AgCl			PdI ₂	I ₂	0.70531
Chromium				2 HI	0.71092
Cr ₂ O ₃	Cr ₂	0.68464		2 IO ₃	0.92721
	2 CrO ₃	1.31538		I ₂ O ₅	0.92773
	2 CrO ₄	1.52563		2 IO ₄	1.06116
	Cr ₂ O ₇	1.42053		I ₂ O ₇	1.01669
BaCrO ₄	Cr	0.20552	Iron		
	CrO ₃	0.39487	Fe ₂ O ₃	Fe ₂	0.70000
	CrO ₄	0.45798		2 FeO	0.89999
2 BaCrO ₄	Cr ₂ O ₃	0.30019		2 FeS	1.10075
	Cr ₂ O ₇	0.42643		2 FeS ₂	1.50152
PbCrO ₄	Cr	0.16130		Fe	0.63593
	CrO ₃	0.30991	FeS	FeO	0.81762
	CrO ₄	0.35944		Fe ₂ O ₃	0.90847
2 PbCrO ₄	Cr ₂ O ₃	0.23560	2 FeS	Fe ₂	0.37086
	Cr ₂ O ₇	0.33468	Fe ₂ (PO ₄) ₂	2 FeO	0.47682
K ₂ Cr ₂ O ₇	Cr ₂	0.35382		Fe ₂ O ₃	0.52980
	Cr ₂ O ₃	0.51680	Lead		
	2 CrO ₃	0.67978	PbO	Pb	0.92822
	2 CrO ₄	0.78844		PbS	1.07206
	Cr ₂ O ₇	0.73412		PbSO ₄	1.35916
Cobalt				Pb	0.86582
Co	CoO	1.27119	PbS	PbO	0.93278
CoO	Co	0.78667		PbSO ₄	1.26780
K ₂ Co(NO ₃) ₆	Co	0.13033	PbCl ₂	Pb	0.74478
	CoO	0.16568		PbO	0.80238
Copper				Pb	0.44920
CuO	Cu	0.79901	PbI ₂	PbO	0.48394
Cu ₂ S	Cu ₂	0.79869		Pb	0.68294
	2 CuO	0.99961	PbSO ₄	PbO	0.73575
	Cu ₂ O	0.89915		PbS	0.78877
Fluorine				Pb	0.64066
CaF ₂	F ₂	0.48718	PbCrO ₄	PbO	0.69010
	2 HF	0.51309		PbS	0.73983
BaSiF ₆	6 F	0.40743			

Weighed as	Required	Factor	Weighed as	Required	Factor
Lead			Phosphorus		
Pb	PbO	1.07733		P ₂ O ₅	0.63757
Manganese				P ₂ O ₇	0.78125
MnO	Mn	0.77464		2 PO ₃	0.70941
Mn ₂ O ₃	3 Mn	0.72051	Fe ₃ (PO ₄) ₂	2 P	0.20530
	3 MnO	0.93012		2 PO ₃	0.62913
	3 MnO ₂	1.55894		P ₂ O ₅	0.47020
MnS	Mn	0.63174	U ₃ P ₃ O ₁₁	2 P	0.086471
	MnO	0.81553		2 PO ₃	0.26499
	MnO ₂	1.36688		P ₂ O ₅	0.19805
MnSO ₄	Mn	0.36409		P ₂ O ₇	0.24268
	MnO	0.47001	24 MoO ₃ P ₂ O ₅	P ₂	0.017232
Magnesium				P ₂ O ₃	0.039467
MgO	Mg	0.60357		Ca ₃ (PO ₄) ₂	0.086159
Mg ₃ P ₂ O ₇	2 Mg	0.21875	Platinum		
	2 MgO	0.36243	NH ₄ Cl, PtCl ₄	Pt	0.43908
MgSO ₄	Mg	0.20229		PtCl ₄	0.75868
	MgO	0.33516		PtCl ₂	1.72791
Mercury				Pt	0.40099
Hg	HgO	1.07989	K ₂ PtCl ₆	PtCl ₄	0.69287
	HgS	1.16006	Potassium		
2 Hg	Hg ₂ O	1.03994	KCl	K	0.52480
	Hg ₂ Cl ₂	1.17698	2 KCl	K ₂ O	0.63203
HgO	Hg	0.92602	K ₂ SO ₄	K ₂	0.44907
	HgS	1.07424		K ₂ O	0.54083
2 HgO	Hg ₂ O	0.96301		2 KCl	0.85570
HgS	Hg	0.86203	K ₂ PtCl ₆	K ₂	0.16118
	HgO	0.93089		K ₂ O	0.19411
Hg ₂ Cl ₂	2 Hg	0.84963		2 KCl	0.30712
	2 HgO	0.91751		K ₂ CO ₃	0.28468
	Hg ₂ O	0.88357	Silicon		
	2 HgS	0.98562	SiF ₄	SiO ₂	0.57855
Molybdenum			SiO ₂	Si	0.47020
MoS ₃	Mo	0.49953		SiO ₂	1.26490
	MoO ₃	0.66604		SiO ₂	1.52980
Nickel			K ₂ SiF ₆	H ₂ SiF ₆	0.65436
NiO	Ni	0.78581		SiO ₂	0.27368
NiSO ₄	Ni	0.37930		SiF ₄	0.47304
	NiO	0.48268	BaSiF ₆	H ₂ SiF ₆	0.51614
Nitrogen				SiO ₂	0.21587
(NH ₄) ₂ PtCl ₆	2 N	0.63292		SiF ₄	0.37312
	2 NO ₂	0.27967	Silver		
	N ₂ O ₅	0.24361	AgCl	Ag	0.75275
	2 N	0.14415	2 AgCl	Ag ₂ O	0.80856
	2 NO ₂	0.63696	AgBr	Ag	0.57443
	N ₂ O ₅	0.55483	2 AgBr	Ag ₂ O	0.61702
BaSO ₄	2 NO ₂	0.53147	AgI	Ag	0.45971
	N ₂ O ₅	0.46295	2 AgI	Ag ₂ O	0.49379
2 AgCN	(CN) ₂	0.19437	AgCN	Ag	0.80502
AgCN	HCN	0.20191	2 AgCN	Ag ₂ O	0.88533
2 NO	N ₂ O ₅	1.26631	Ag	HCN	0.25036
	N ₂ O ₃	1.79895	Sodium		
Palladium			NaCl	Na	0.39407
PdI ₂	Pd	0.29469	2 NaCl	Na ₂ O	0.53076
Phosphorus			Na ₂ SO ₄	Na ₂	0.32428
P ₂ O ₅	2 P	0.43662		Na ₂ O	0.43683
Mg ₃ P ₂ O ₇	2 P	0.27837		2 NaCl	0.82302
	2 PO ₃	0.85308	Na ₂ H ₂ Sb ₂ O ₇	2 Na	0.11522

Weighed as	Required	Factor	Weighed as	Required	Factor
Sodium			Thallium		
	Na ₂ O	0.15520	Tl ₂ PtCl ₆	2 Tl	0.50043
	2 NaCl	0.29242		Tl ₂ O	0.52004
Na ₂ CO ₃	2 Na	0.43449		2 TlCl	0.58735
	Na ₂ O	0.58529	Tin		
Strontium			SnO ₂	Sn	0.78737
Sr(NO ₃) ₂	Sr	0.41383	Titanium		
	SrO	0.48942	TiO ₂	Ti	0.60051
SrSO ₄	Sr	0.47697		TiO ₂	1.19975
	SrO	0.56409		TiO ₂	1.39952
	SrCl ₂	0.86302	Tungsten		
SrCO ₃	Sr	0.59349	WO ₃	W	0.79310
	SrO	0.70189	Uranium		
	SrCl ₂	1.07384	U ₂ O ₅	3 U	0.84879
Sulphur			U ₂ P ₂ U ₁₁	U ₂	0.66807
BaSO ₄	S	0.13732		2 UO ₂	0.75732
	SO ₂	0.27439		U ₂	0.71568
	SO ₃	0.34293	K ₂ U ₂ O ₇		
	H ₂ SO ₄	0.42011	Vanadium		
	H ₂ S	0.14598	V ₂ O ₅	2 V	0.56141
	3 S	0.39069	Zinc		
As ₂ S ₃	3 H ₂ S	0.41531	ZnO	Zn	0.80345
	S	0.22255		ZnS	1.19732
CdS	H ₂ S	0.23657	ZnS	Zn	0.67104
				ZnO	0.83520
Thallium			Zirconium		
TlI	Tl	0.61671	ZrO ₂	Zr	0.73899
2 TlI	Tl ₂ O	0.64088			

Comparison of Twaddell degrees with Baumé degrees.

Tw	Bé	S. G.	Tw	Bé	S. G.	Tw	Bé	S. G.	Tw	Bé	S. G.
0	0	1.000	44	26.0	1.220	88	44.1	1.440	132	57.4	1.660
1	0.7	1.005	45	26.4	1.225	89	44.4	1.445	133	57.7	1.665
2	1.4	1.010	46	26.9	1.230	90	44.8	1.450	134	57.9	1.670
3	2.1	1.015	47	27.4	1.235	91	45.1	1.455	135	58.2	1.675
4	2.7	1.020	48	27.9	1.240	92	45.4	1.460	136	58.4	1.680
5	3.4	1.025	49	28.4	1.245	93	45.8	1.465	137	58.7	1.685
6	4.1	1.030	50	28.8	1.250	94	46.1	1.470	138	58.9	1.690
7	4.7	1.035	51	29.3	1.255	95	46.4	1.475	139	59.2	1.695
8	5.4	1.040	52	29.7	1.260	96	46.8	1.480	140	59.5	1.700
9	6.0	1.045	53	30.2	1.265	97	47.1	1.485	141	59.7	1.705
10	6.7	1.050	54	30.6	1.270	98	47.4	1.490	142	60.0	1.710
11	7.4	1.055	55	31.1	1.275	99	47.8	1.495	143	60.2	1.715
12	8.0	1.060	56	31.5	1.280	100	48.1	1.500	144	60.4	1.720
13	8.7	1.065	57	32.0	1.285	101	48.4	1.505	145	60.6	1.725
14	9.4	1.070	58	32.4	1.290	102	48.7	1.510	146	60.9	1.730
15	10.0	1.075	59	32.8	1.295	103	49.0	1.515	147	61.1	1.735
16	10.6	1.080	60	33.3	1.300	104	49.4	1.520	148	61.4	1.740
17	11.2	1.085	61	33.7	1.305	105	49.7	1.525	149	61.6	1.745
18	11.9	1.090	62	34.2	1.310	106	50.0	1.530	150	61.8	1.750
19	12.4	1.095	63	34.6	1.315	107	50.3	1.535	151	62.1	1.755
20	13.0	1.100	64	35.0	1.320	108	50.6	1.540	152	62.3	1.760
21	13.6	1.105	65	35.4	1.325	109	50.9	1.545	153	62.5	1.765
22	14.2	1.110	66	35.8	1.330	110	51.2	1.550	154	62.8	1.770
23	14.9	1.115	67	36.2	1.335	111	51.5	1.555	155	63.0	1.775
24	15.4	1.120	68	36.6	1.340	112	51.8	1.560	156	63.2	1.780
25	16.0	1.125	69	37.0	1.345	113	52.1	1.565	157	63.5	1.785
26	16.5	1.130	70	37.4	1.350	114	52.4	1.570	158	63.7	1.790
27	17.1	1.135	71	37.8	1.355	115	52.7	1.575	159	64.0	1.795
28	17.7	1.140	72	38.2	1.360	116	53.0	1.580	160	64.2	1.800
29	18.3	1.145	73	38.6	1.365	117	53.3	1.585	161	64.4	1.805
30	18.8	1.150	74	39.0	1.370	118	53.6	1.590	162	64.6	1.810
31	19.3	1.155	75	39.4	1.375	119	53.9	1.595	163	64.8	1.815
32	19.8	1.160	76	39.8	1.380	120	54.1	1.600	164	65.0	1.820
33	20.3	1.165	77	40.1	1.385	121	54.4	1.605	165	65.2	1.825
34	20.9	1.170	78	40.5	1.390	122	54.7	1.610	166	65.5	1.830
35	21.4	1.175	79	40.8	1.395	123	55.0	1.615	167	65.7	1.835
36	22.0	1.180	80	41.2	1.400	124	55.2	1.620	168	65.9	1.840
37	22.5	1.185	81	41.6	1.405	125	55.5	1.625	169	66.1	1.845
38	23.0	1.190	82	42.0	1.410	126	55.8	1.630	170	66.3	1.850
39	23.5	1.195	83	42.3	1.415	127	56.0	1.635	171	66.5	1.855
40	24.0	1.200	84	42.7	1.420	128	56.3	1.640	172	66.7	1.860
41	24.5	1.205	85	43.1	1.425	129	56.6	1.645	173	67.0	1.865
42	25.0	1.210	86	43.4	1.430	130	56.9	1.650			
43	25.5	1.215	87	43.8	1.435	131	57.1	1.655			

$$\text{If } d \text{ be the S.G. and } n \text{ the degree B , } d = \frac{144.3}{144.3 - n}.$$

$$\text{If } d \text{ be the S.G. and } n \text{ the degree Twaddell, } n = (d - 1) 200.$$

Atomic Weights of the Elements (1909).

Name	Atomic weight	Sym- bol	Name	Atomic weight	Sym- bol
Aluminium	27.1	Al	Neodymium	144.3	Nd
Antimony	120.2	Sb	Neon	20.00	Ne
Argon	39.9	A	Nickel	58.68	Ni
Arsenic	75.0	As	Niobium	93.5	Nb
Barium	137.37	Ba	Nitrogen	14.01	N
Beryllium	9.1	Be	Osmium	190.9	Os
Bismuth	208.0	Bi	Oxygen	16.00	O
Boron	11.0	B	Palladium	106.7	Pd
Bromine	79.92	Br	Phosphorus	31.0	P
Cadmium	112.40	Cd	Platinum	195.0	Pt
Cæsium	132.81	Cs	Potassium	39.1	K
Calcium	40.09	Ca	Præcodymium	140.6	Pr
Carbon	12.00	C	Radium	226.4	Ra
Cerium	140.25	Ce	Rhodium	102.9	Rh
Chlorine	35.46	Cl	Rubidium	85.45	Rb
Chromium	52.1	Cr	Ruthenium	101.7	Ru
Cobalt	58.97	Co	Samarium	150.4	Sa
Copper	63.57	Cu	Scandium	44.1	Sc
Dysprosium	162.5	—	Selenium	79.2	Se
Erbium	167.4	Er	Silicon	28.3	Si
Fluorine	19.0	F	Silver	107.88	Ag
Gallium	69.9	Ga	Sodium	23.00	Na
Germanium	72.5	Ge	Strontium	87.62	Sr
Gold	197.2	Au	Sulphur	32.07	S
Holmium	4.0	Ho	Tantalum	181.0	Ta
Hydrogen	1.008	H	Tellurium	127.5	Te
Indium	114.8	In	Terbium	159.2	Tb
Iodine	126.92	I	Thallium	204.0	Tl
Iridium	193.1	Ir	Thorium	232.42	Th
Iron	55.85	Fe	Tin	119.0	Sn
Krypton	81.8	Kr	Titanium	48.1	Ti
Lanthanum	139.0	La	Tungsten	184.0	W
Lead	207.10	Pb	Uranium	238.5	U
Lithium	7.00	Li	Vanadium	51.2	V
Lutetium	174.0	Lu	Xenon	128.0	Xe
Magnesium	24.32	Mg	Ytterbium	173.0	Yb
Manganese	54.93	Mn	Yttrium	89.0	Y
Mercury	200.0	Hg	Zinc	65.37	Zn
Molybdenum	96.0	Mo	Zirconium	90.6	Zr

Multiples of Atomic Weights.

	1	2	3	4	5	6	7	8	9	10
Aluminium	27.1	54.2	81.3	108.4	135.5	162.6	189.7	216.8	243.9	271
Antimony	120	240	360	480	600	720	840	960	1080	1200
Arsenic	75	150	225	300	375	450	525	600	675	750
Barium	137.4	274.8	412.2	549.6	687	824.4	961.8	1099.2	1236.6	1374
Beryllium	9.1	18.2	27.3	36.4	45.5	54.6	63.7	72.8	81.9	91
Bismuth	208.5	417	625.5	834	1042.5	1251	1459.5	1668	1876.5	2085
Boron	11	22	33	44	55	66	77	88	99	110
Bromine	79.96	159.92	239.88	319.84	399.8	479.76	559.72	639.68	719.64	799.6
Cadmium	112	224	336	448	560	672	784	896	1008	1120
Caesium	133	266	399	532	665	798	931	1064	1197	1330
Calcium	40	80	120	160	200	240	280	320	360	400
Carbon	12	24	36	48	60	72	84	96	108	120
Cerium	140	280	420	560	700	840	980	1120	1260	1400
Chlorine	35.45	70.9	106.35	141.8	177.25	212.7	248.15	283.6	319.05	354.5
Chromium	52.1	104.2	156.3	208.4	260.5	312.6	364.7	416.8	468.9	521
Cobalt	59	118	177	236	295	354	413	472	531	590
Copper	63.6	127.2	190.8	254.4	318	381.6	445.2	508.8	572.4	636
Erbium	168	332	498	664	830	996	1162	1328	1494	1660
Fluorine	19	38	57	76	95	114	133	152	171	190
Gallium	70	140	210	280	350	420	490	560	630	700
Germanium	72	144	216	288	360	432	504	576	648	720
Gold	197.2	394.4	591.6	788.8	986	1183.2	1380.4	1577.6	1774.8	1972
Hydrogen	1.01	2.02	3.03	4.04	5.05	6.06	7.07	8.08	9.09	10.1
Indium	114	228	342	456	570	684	798	912	1026	1140
Iodine	126.85	253.7	380.55	507.4	634.25	761.1	887.95	1014.8	1141.65	1268.5
Iridium	193	386	579	772	965	1158	1351	1544	1737	1930
Iron	56	112	168	224	280	336	392	448	504	560
Lead	207.2	414.4	621.6	828.8	1036	1243.2	1450.4	1657.6	1864.8	2072
Lanthanum	138	276	414	552	690	828	966	1104	1242	1380
Lithium	7.03	14.06	21.09	28.12	35.15	42.18	49.21	56.24	63.27	70.3
Magnesium	24.36	48.72	73.08	97.44	121.8	146.16	170.52	194.88	219.24	243.6
Manganese	55	110	165	220	275	330	385	440	495	550
Mercury	200.3	400.6	600.9	801.2	1001.5	1201.8	1402.1	1602.4	1802.7	2003

	1	2	3	4	5	6	7	8	9	• 10
Molybdenum	96	192	288	• 384	480	576	672	768	864	960
Nickel	58.7	117.4	176.1	234.8	293.5	352.2	410.9	469.6	528.3	587
Niobium	94	188	282	• 376	470	564	658	752	846	940
Nitrogen	14.04	28.08	42.12	56.16	70.2	84.24	98.28	112.32	126.36	140.4
Osmium	191	382	573	764	955	1146	1337	1528	1719	1910
Oxygen	16	32	48	64	80	96	112	128	144	160
Palladium	106	212	318	424	530	636	742	848	954	1060
Phosphorus	31	62	93	124	155	186	217	248	279	310
Platinum	194.8	389.6	584.4	779.2	974	1168.8	1363.6	1558.4	1753.2	1948
Potassium	39.15	78.3	117.45	156.6	195.75	234.9	274.05	313.2	352.35	391.5
Rhodium	103	206	309	412	515	618	721	824	927	1030
Rubidium	85.4	170.8	256.2	341.6	427	512.4	597.8	683.2	768.6	854
Ruthenium	101.7	203.4	305.1	406.8	508.5	610.2	711.9	813.6	915.3	1017
Samarium	150	300	450	600	750	900	1050	1200	1350	1500
Scandium	44.1	88.2	132.3	176.4	220.5	264.6	308.7	352.8	396.9	441
Selenium	79.1	158.2	237.3	316.4	395.5	474.6	553.7	632.8	711.9	791
Silicon	28.4	56.8	85.2	113.6	142	170.4	198.8	227.2	255.6	284
Silver	107.93	215.86	323.79	431.72	539.65	647.58	755.51	863.44	971.37	1079.3
Sodium	23.05	46.1	69.15	92.2	115.25	138.3	161.35	184.4	207.45	230.5
Strontium	87.6	175.2	262.8	350.4	438	525.6	613.2	700.8	788.4	876
Sulphur	32.06	64.12	96.18	128.24	160.3	192.36	224.42	256.48	288.54	320.6
Tantalum	183	366	549	732	915	1098	1281	1464	1647	1830
Tellurium	127	254	381	508	635	762	889	1016	1143	1270
Thallium	204.1	408.2	612.3	816.4	1020.5	1224.6	1428.7	1632.8	1836.9	2041
Thorium	232	464	696	928	1160	1392	1624	1856	2088	2320
Tin	118.5	237	355.5	474	592.5	711	829.5	948	1066.5	1185
Titanium	48.1	96.2	144.3	192.4	240.5	288.6	336.7	384.8	432.9	481
Tungsten	184	368	552	736	920	1104	1288	1472	1656	1840
Uranium	238	476	714	952	1190	1428	1666	1904	2142	2380
Vanadium	51.2	102.4	153.6	204.8	256	307.2	358.4	409.6	460.8	512
Xenon	131.3	262.6	393.9	525.2	656.5	787.8	919.1	1050.4	1181.7	1313
Ytterbium	173	346	519	692	865	1038	1211	1384	1557	1730
Yttrium	89	178	267	356	445	534	623	712	801	890
Zinc	65.4	130.8	196.2	261.6	327	392.4	457.8	523.2	588.6	654
Zirconium	90.6	181.2	271.8	362.4	453	543.6	634.2	724.8	815.4	906

